BRITISH COLUMBIA

Ministry of Energy and Mines
Resource Development and
Geoscience Branch

# Coalbed Gas Potential in British Columbia

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# PETROLEUM GEOLOGY PAPER 2004 - 1

# Coalbed Gas Potential in British Columbia

This publication was researched and compiled by Total Earth Science Services with expert guidance and in coordination with Barry Ryan of the British Columbia Ministry of Energy and Mines.

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# INTRODUCTION

This publication provides a brief overview of the major coalfields in British Columbia and their coalbed gas potential (coalbed gas (CBG) is often referred to as coalbed methane (CBM)). Each coalfield is summarized and illustrated with simple figures, images and tables.

At present there are no producing coalbed gas wells in British Columbia but within western Canada and especially British Columbia there is tremendous incentive and opportunity to develop coalbed gas resources.

The major coalfields of British Columbia are grouped into Rocky Mountain, Insular and Intermontane belts. The Insular Belt includes the coalfields and deposits on Vancouver Island and small deposits on the Queen Charlotte Islands to the north. The Intermontane Belt includes a number of coalfields and deposits through the centre of the province and the Rocky Mountain Belt includes the important coalfields in the southeast and northeast of the province, where most of the mines are located. About 80 per cent of the coal resource in the province is contained in the Upper Jurassic to Lower Cretaceous coalfields in the Rocky Mountain Belt.

British Columbia has an estimated coal resource in the range of 250 billion tonnes to a depth of 2000 metres that is available for coalbed gas exploration. The potential coalbed gas resource in this coal is about 90 Tcf but the percentage of this resource that may eventually be recoverable will be much less.

Published coalbed gas resource assessments for the East Kootenay coalfields in the southeast corner of the province indicate potential for more than 14 Tcf and for northwest British Columbia 8 Tcf (Ryan and Dawson, 1993). Ryan (2003) estimates a resource of about 60 Tcf for the Peace River Coalfield in the northeast and 0.3 to 1.6 Tcf. for Vancouver Island coalfields. If gas contents are 1 to 3 cm$^3$/g at Hat Creek, there could be a sizable coalbed gas resource of over 0.5 Tcf concentrated in a small area.

With a well developed network of gas pipelines, British Columbia affords exceptional opportunities to those interested in the development of coalbed gas.

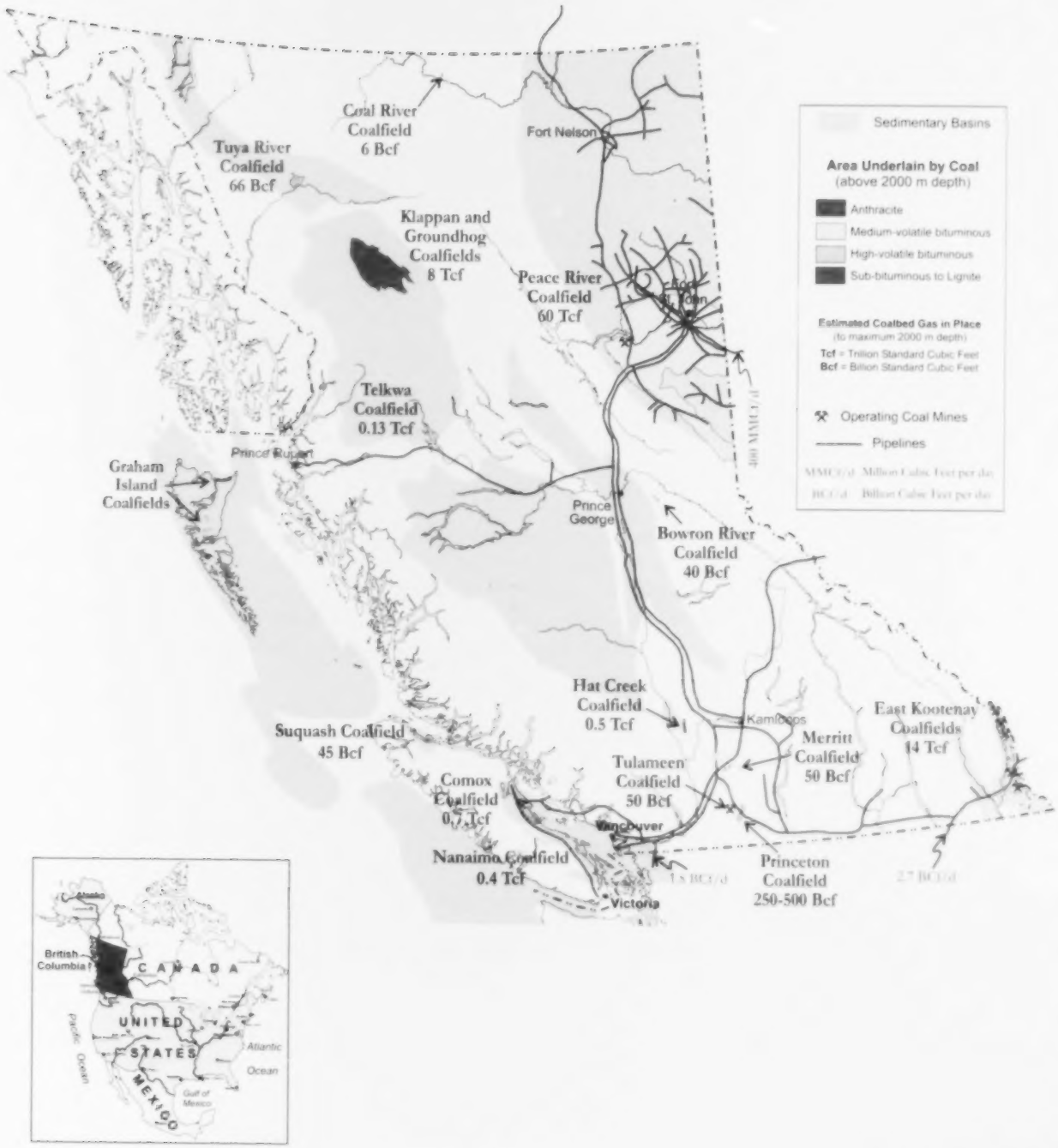
If you would like to know more about opportunities for coalbed gas in British Columbia, visit the Ministry of Energy and Mines website at:

**www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/cbg.htm**

We encourage you to contact us for additional data required to initiate your exploration program in British Columbia.

**Coalbed Gas Team**
Phone: (250) 952-0408
E-mail: CBGInfo@gems9.gov.bc.ca

# Coalfields and Coalbed Gas Potential in British Columbia



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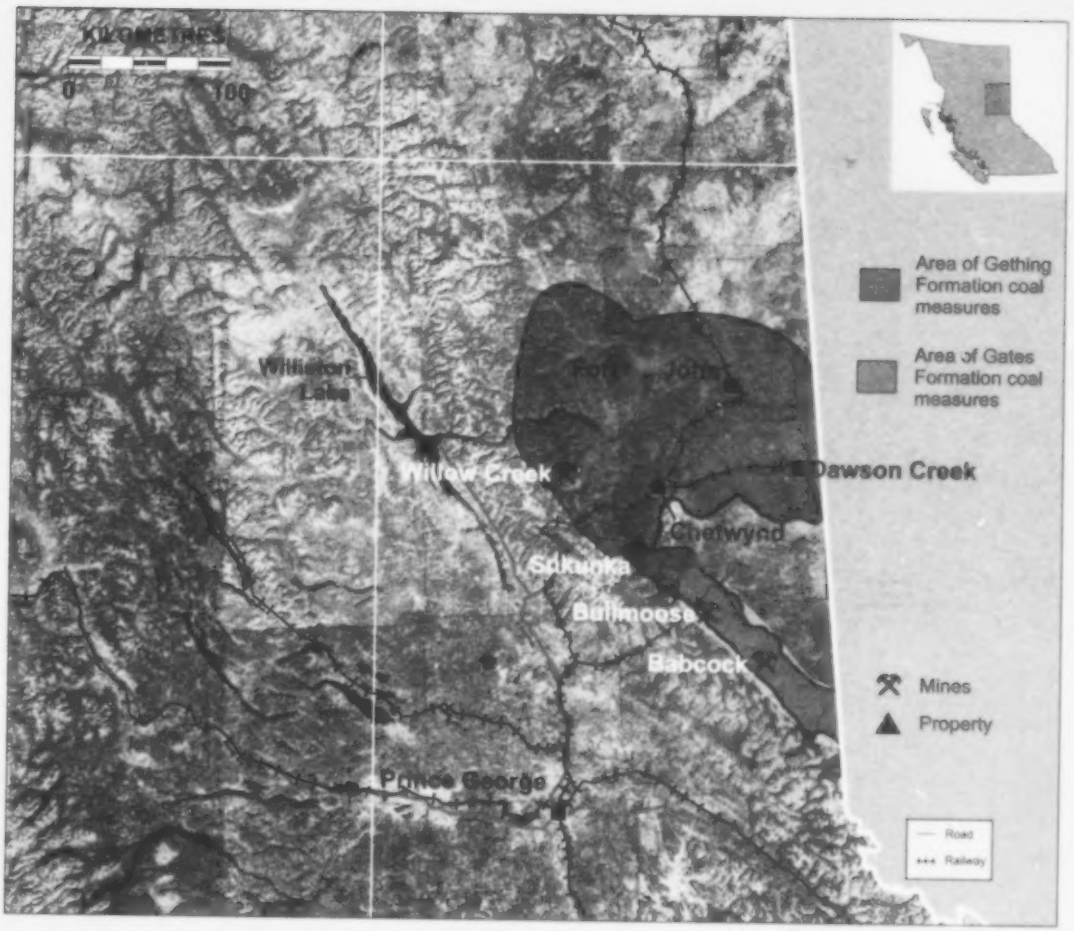
# Peace River Coalfield

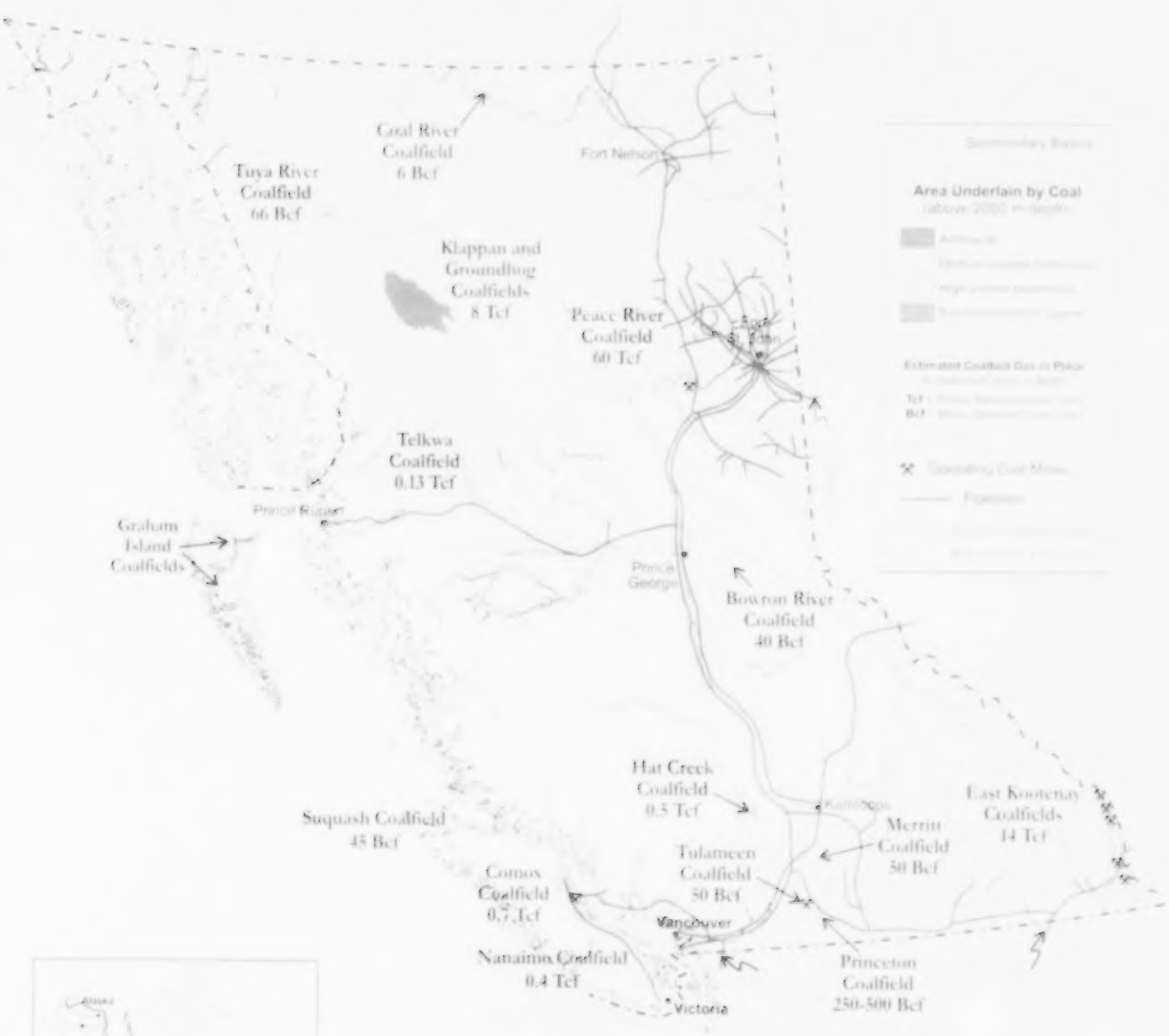



The northern Inner Foothills Belt, called the Peace River Coalfield, extends 400 kilometres from the Kakwa to the Sikanni rivers in northeastern British Columbia. The coalfield contains a number of coal-bearing units that dip to the east into the Western Canadian Sedimentary Basin. In order of decreasing age these are the Jura-Cretaceous Minnes Group and Lower Cretaceous Gething and Gates formations.

The coal resource in the Peace River Coalfield to a depth of 2000 metres is estimated to be more than 160 billion tonnes of medium and low-volatile bituminous coal. This is mainly divided between the Gates (10 billion tonnes plus) and Gething formations (120 billion tonnes plus). To date, two major mines (Quintette and Bullmoose) were developed in the Gates but have recently closed.

Coalbed gas potential in the area is largely restricted to the Gething and the Gates formations but potential also exists in the Minnes Group and Upper Cretaceous strata. A conservative estimate of gas content in the coalfield is 60 Tcf. Pipeline infrastructure is already well-developed in this area, the heartland of province's oil and gas industry.

# Coalfields and Coalbed Gas Potential in British Columbia



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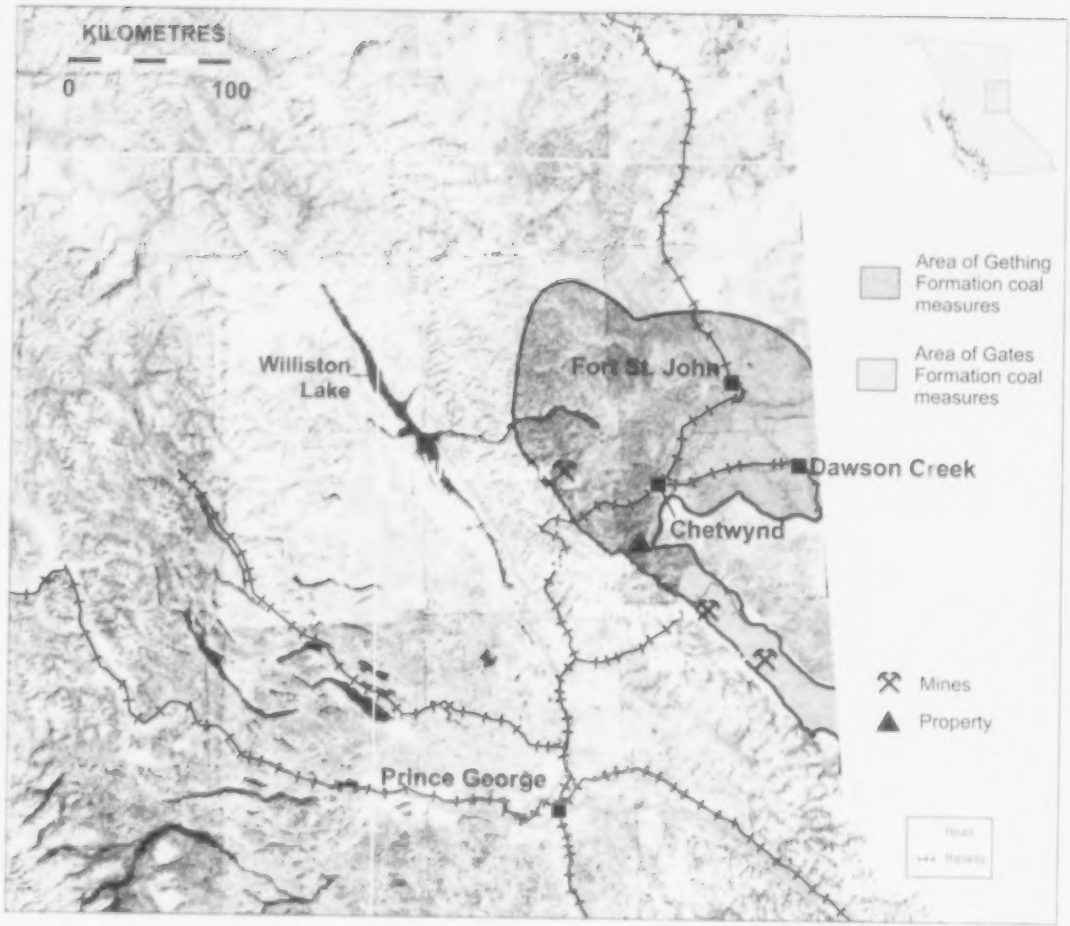


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Map of Peace River Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

Map of Peace River Coalfield

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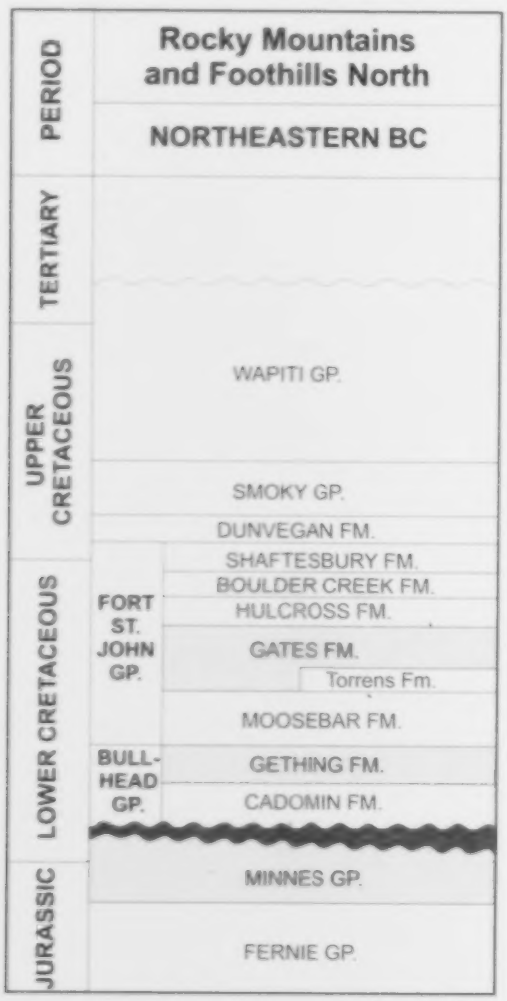
## Coal

- The lower Gething Formation contains coal over an extensive area, though the best development is in the area between the Sukunka and Pine rivers. The formation is enclosed by the underlying Cadomin conglomerate and the overlying Bluesky conglomerate, above which is the marine Moosebar Formation. This formation is overlain by the coal-bearing Gates Formation, which contains coal from the Sukunka River southeast to the Alberta border. The deformed belt of the coalfield (Inner Foothills), which trends northwest, is defined by the outcrop of the Gething Formation on the west and a number of major thrusts on the east; the main one being the Gwillam Lake Thrust. East of the thrusts, Cretaceous beds dip into the trough of the Western Canadian Sedimentary Basin and are in places too deep to be of interest for coalbed gas development. Fold style is generally chevron with well-developed flat limbs and shorter steep dipping limbs. Regional thrusts are west dipping, though at least at Willow Creek reverse faults and axial planes dip steeply to the east.




(Smith, 1989)

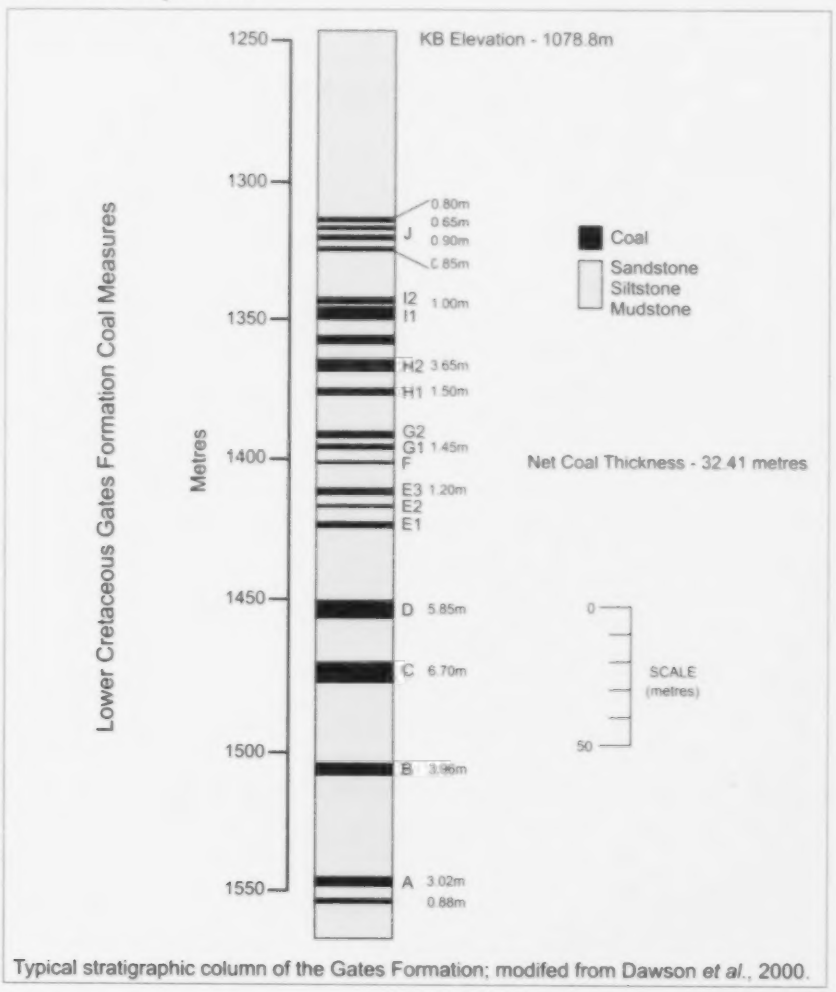
## Gates

- The Gates Formation contains coal from the Sukunka River south to the Saxon property near the Alberta border, although thicknesses appear to thin to the east at depth in the equivalent formation (Falher Formation).

- The formation is mainly medium-volatile bituminous but ranks on the western margin of the coalfield are lower.

- The formation is up to 280 metres thick and contains four or five laterally extensive seams ranging in thickness from 5 to 10 metres that have an aggregate thickness of up to 46 metres.

- Two major mines (Quintette and Bullmoose) in the formation were established by the early 1980s and several other properties have reached advanced stages of exploration. Quintette closed in 2000 and Bullmoose in 2003. Western Canadian Coal Corporation is applying for a mining lease on a property near the Quintette Mine called Perry Creek.



Typical stratigraphic column of the Gates Formation; modifed from Dawson *et al.*, 2000.

| Shipped Coal<br>Gates Formation (Bullmoose Mine) | |
|---|---|
| Moisture (shipped) (%) | 8.0 |
| Ash (db) (%) | 8.5 |
| Volatile matter (db) (%) | 26.6 |
| Fixed carbon (db) (%) | 56.9 |
| Sulphur (db) (%) | 0.4 |
| Btu/lb | 13,800 |
| Mj/kg (adb net) | 30.18 |
| FSI | 5.5 - 7 |
| Hardgrove Index | 70 - 80 |
| Rmax (%) (average) | 1.1 |

(Ryan, 2002)

### Gething

- The Gething Formation is up to 1036 metres thick and contains more than 100 coal beds ranging in thickness from a few centimetres to 4.3 metres. The formation underlies a large area of the Peace River Coalfield.

- The best coal development is between Williston Lake and Sukunka River to the south though the formation also contains coal at depth to the east towards Dawson Creek. South of Sukunka River the formation is thin and contains only a few seams.

- Coal rank is generally medium-volatile bituminous but decreases to the north and northeast toward Williston Lake. West and north of Sukunka River, rank increases to low-volatile bituminous.

- There has been limited mining in the Gething Formation despite the fact that it hosts the first coal to be discovered in British Columbia in 1793. More recently the Pine Valley Mining Corporation has obtained permits for a mine in the Willow Creek area.

### Minnes

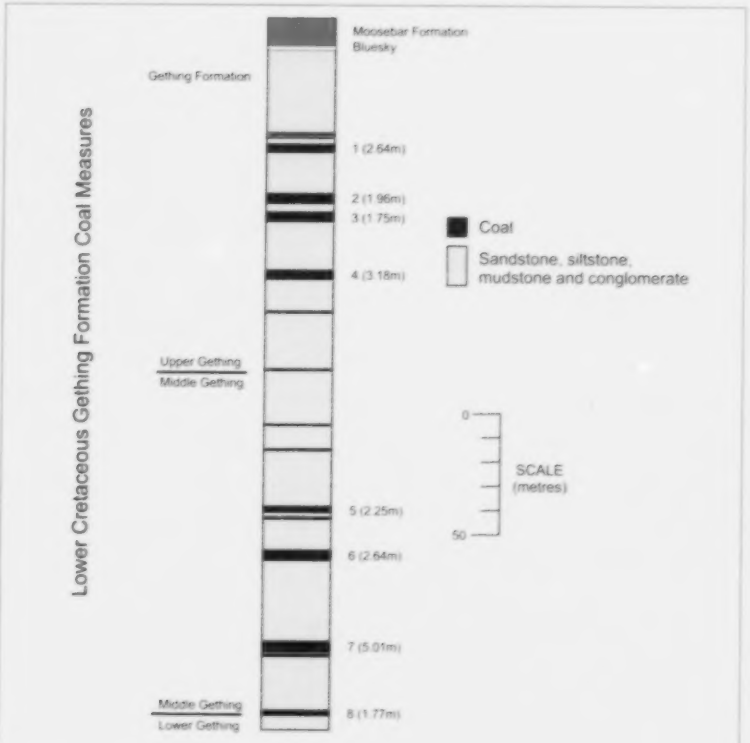
- Strata of the Minnes Group occupy a large area of surface bedrock of the Foothills Belt and is equivalent to the Nikanassin and Mist Mountain formations to the south.

## Coalbed Gas

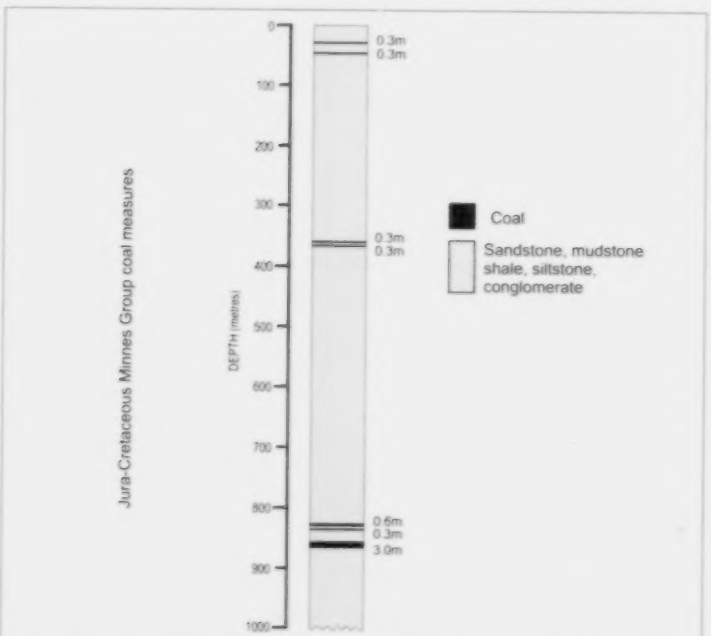
- The coalbed gas potential for the Peace River Coalfield is enormous and has variously been calculated to be between 60 and 200 Tcf. This is an estimate based on coal quantities and preliminary data and should be treated with caution.

- Existing coalbed gas exploration in the Peace River Coalfield falls into a number of phases:

  - Estimates were made of desorbed gas contents of samples collected from shallow holes during coal exploration from 1975 to 1985. These data were



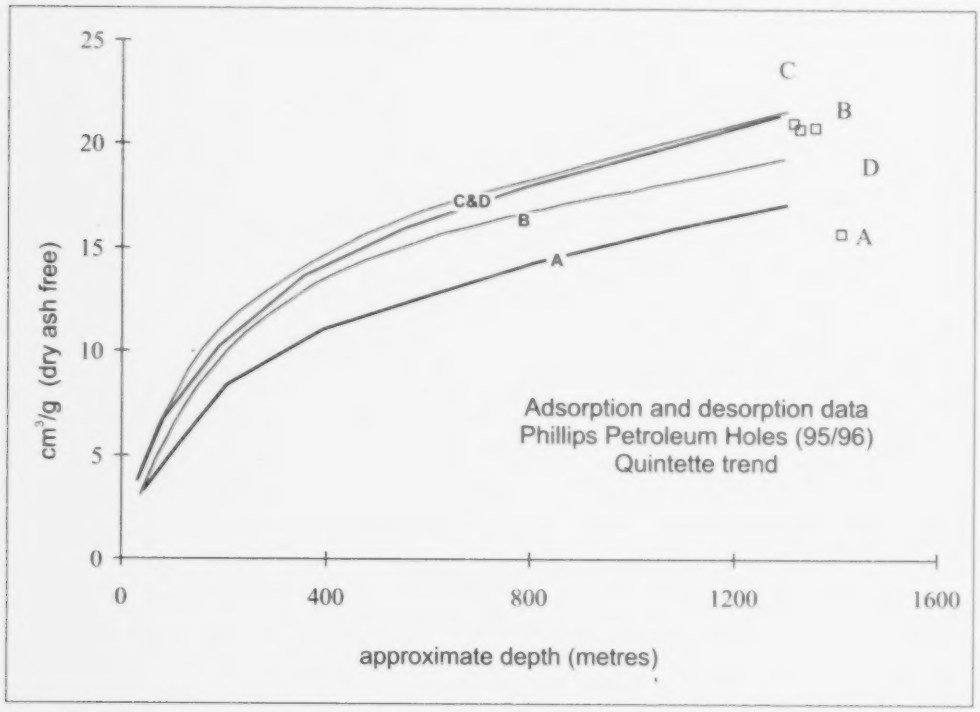

Representative stratigraphic column of the Gething Formation at Willow Creek, simplified from Kevin James (personal communication).




Stratigraphic column derived from Mount Minnes section description by Ziegler and Pocock (1960). Coal seams are shown at the correct depth but are not to scale. Value to right of seam indicates actual thickness.

collected as part of the appraisal of the underground coal mining potential of a number of properties. The data generally indicate low gas contents, but the data are old and were collected at shallow depths and may have little relevance to coalbed gas resource evaluation.

- In 1996, Phillips Petroleum drilled four holes in the Monkman area (Gates Formation) and the data are summarized in Dawson et al. (2000). The holes intersected cumulative coal thicknesses averaging 20 metres at depths ranging from 1200 to 1550 metres. Gas contents ranged from 6 to 26 $cm^3/g$ on an as received basis. Comparisons of desorption and adsorption data indicate that the seams are close to saturated. Low permeabilities were encountered. Four adsorption isotherms from samples from one of the Phillips wells gave Langmuir volumes ranging from 19.8 to 25 $cm^3/g$ on an as-received basis.




- Adsorption work done on samples from Gates coals (Lamberson and Bustin, 1992) and Gething Formation (Ryan and Lane, 2002) confirmed the high adsorption capacity of coals from these formations and documents the changes in capacity related to varying maceral compositions.

- A number of exploration holes have been drilled in the last few years. Most of the data from these holes are still confidential but will start to become public by 2004.

- Potential for coalbed gas exists in the older Minnes Group but little research has been done on its coal measures.

**Key References** (see Appendix I, References)


Dawson, F.M., Marchioni, D.L., Anderson, T.C. and McDougall, W.J. (2000): An Assessment of Coalbed Methane Exploration Projects in Canada; *Geological Survey of Canada*, Bulletin 549.

Lamberson, M.N. and Bustin, R.M. (1992): Coalbed Methane Characteristics of the Gates Formation Lithotypes, Northeastern British Columbia; *Canadian Coal and Coal Bed Methane Geoscience Forum*, Proceedings, pages 275-284.

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Ryan, B. (2002): Coal in British Columbia; *B.C. Ministry of Energy and Mines*, Website, http://www.em.gov.bc.ca/Mining/Geolsurv/coal/coalinbc/coal_bc.htm.

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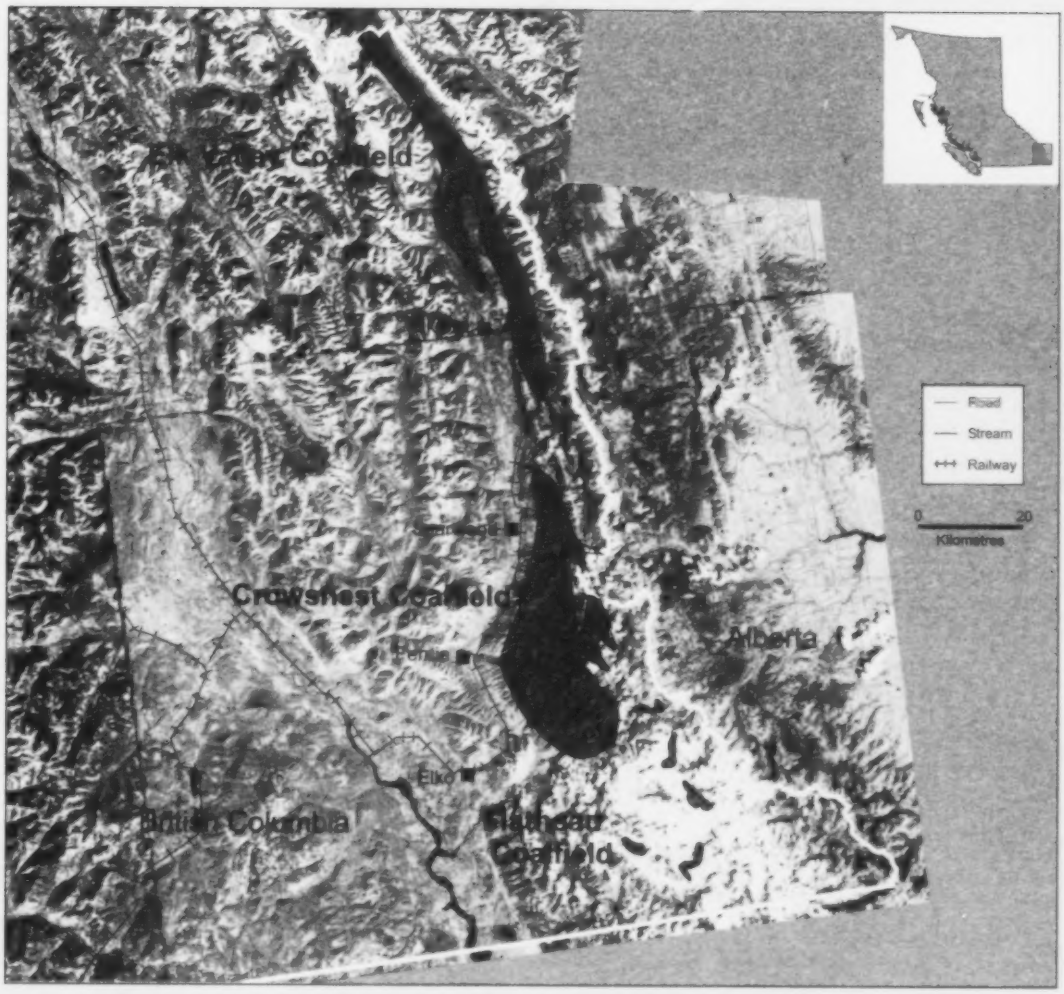
Smith, G.G. (1989): Coal Resources of Canada; *Geological Survey of Canada*, Paper 89-4.

Zieglar, W.H. and Pocock, S.A.J. (1960): The Minnes Formation; *Edmonton Geological Society*, Second Annual Field Trip Guide Book, Rock Lake, pages 43-67.

# East Kootenay Coalfields

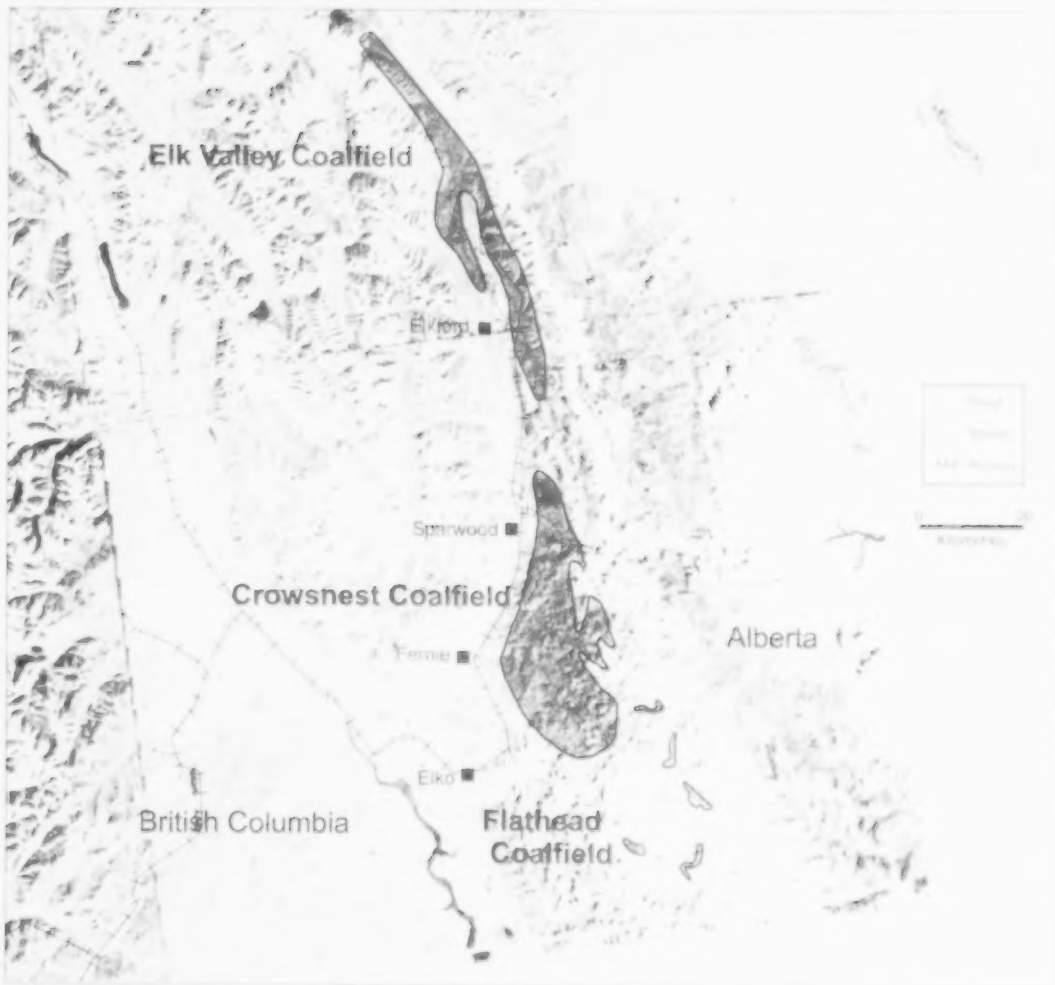



The southeast corner of the province, often referred to as the East Kootenay region, contains three separate coalfields known respectively as Crowsnest, Elk Valley and Flathead. Since 1898, these coalfields have produced over 500 million tonnes of mainly coking coal and presently host five active mines.

Coal occurs in the Mist Mountain Formation of the Jurassic-Cretaceous Kootenay Group. The formation averages 500 to 600 metres in thickness and contains from 4 to 30 plus seams; cumulative coal thickness ranges up to over 60 metres. Seams range in rank from high to low-volatile bituminous.

Coalbed gas resource assessments for the East Kootenay coalfields indicate potential for more than 14 Tcf.

# East Kootenay Coalfields

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## Elk Valley Coalfield

### Coal

- The coal resource to a depth of 1500 metres in the Elk Valley Coalfield is estimated to be 19 billion tonnes (Johnson and Smith, 1991).

- There are three mines in the Elk Valley Coalfield. In the south, the Line Creek mine produces medium-volatile hard coking coal and lesser amounts of thermal coal. In the northern part of the coalfield, the Greenhills and Fording River mines produce medium and high-volatile coking coal from a large number of seams through a thick Mist Mountain Formation section.

- The coalfield contains two north-trending synclines separated by a major normal fault. The Bourgeau Thrust defines the west edge of the coalfield.

- Seams are folded and thrust faulted in both synclines. Thicker seams are developed low in the section but tend to host major thrusts, consequently some are extensively sheared.

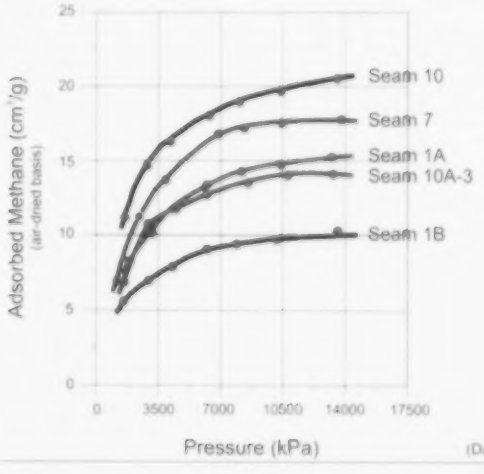
### Coalbed Gas

- There is an estimated coalbed potential gas resource of 7.7 Tcf in the Elk Valley Coalfield (Johnson and Smith, 1991).

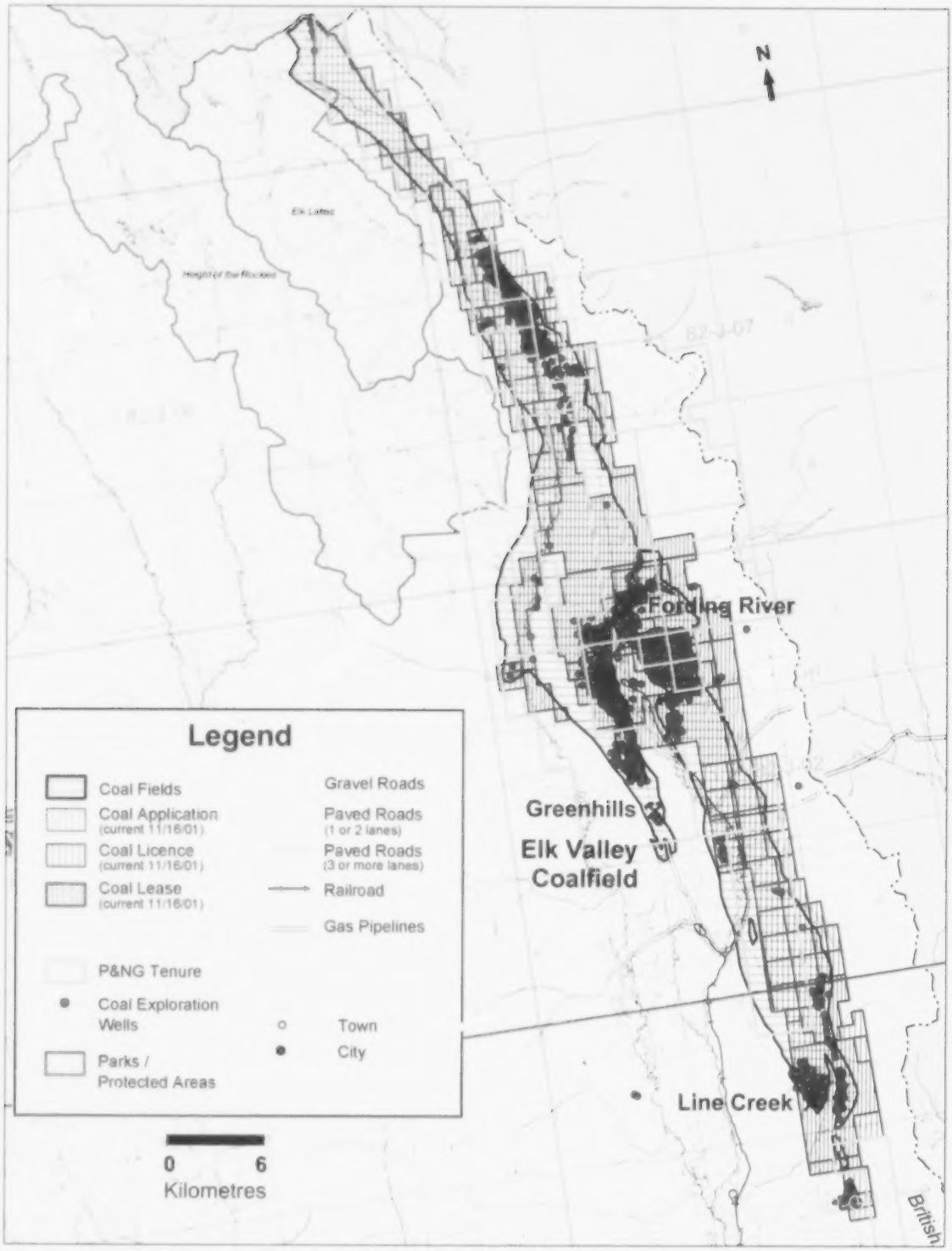
Adsorption Isotherms of coal samples from the Mist Mountain Formation, Elk Valley Coalfield

| Coal Seams | 1A | 1B | 7 | 10 | 10A-3 |
|---|---|---|---|---|---|
| Adsorption Temperature (°C) | 22 | 22 | 22 | 22 | 22 |
| Ash Content (%) | 12.06 | 23.26 | 7.26 | 3.69 | 10.75 |
| Equilibrium Moisture Content (%) | 1.5 | 1.8 | 2.1 | 2.9 | 1.35 |
| Langmuir Volume ($cm^3/g$) | 17.39 | 11.42 | 19.51 | 23.43 | 15.43 |
| Langmuir Volume ($cm^3/g$) (ash corrected) | 19.78 | 14.88 | 21.03 | 24.33 | 17.28 |
| Langmuir Pressure (kPa) | 1880 | 1582 | 1838 | 2018 | 1540 |
| $R_{max}$ (%) | 1.2 | 1.2 | 1.16 | 1.14 | 1.39 |

Note: Seams 1A, 10A-3 and 1B are stratigraphically equivalent

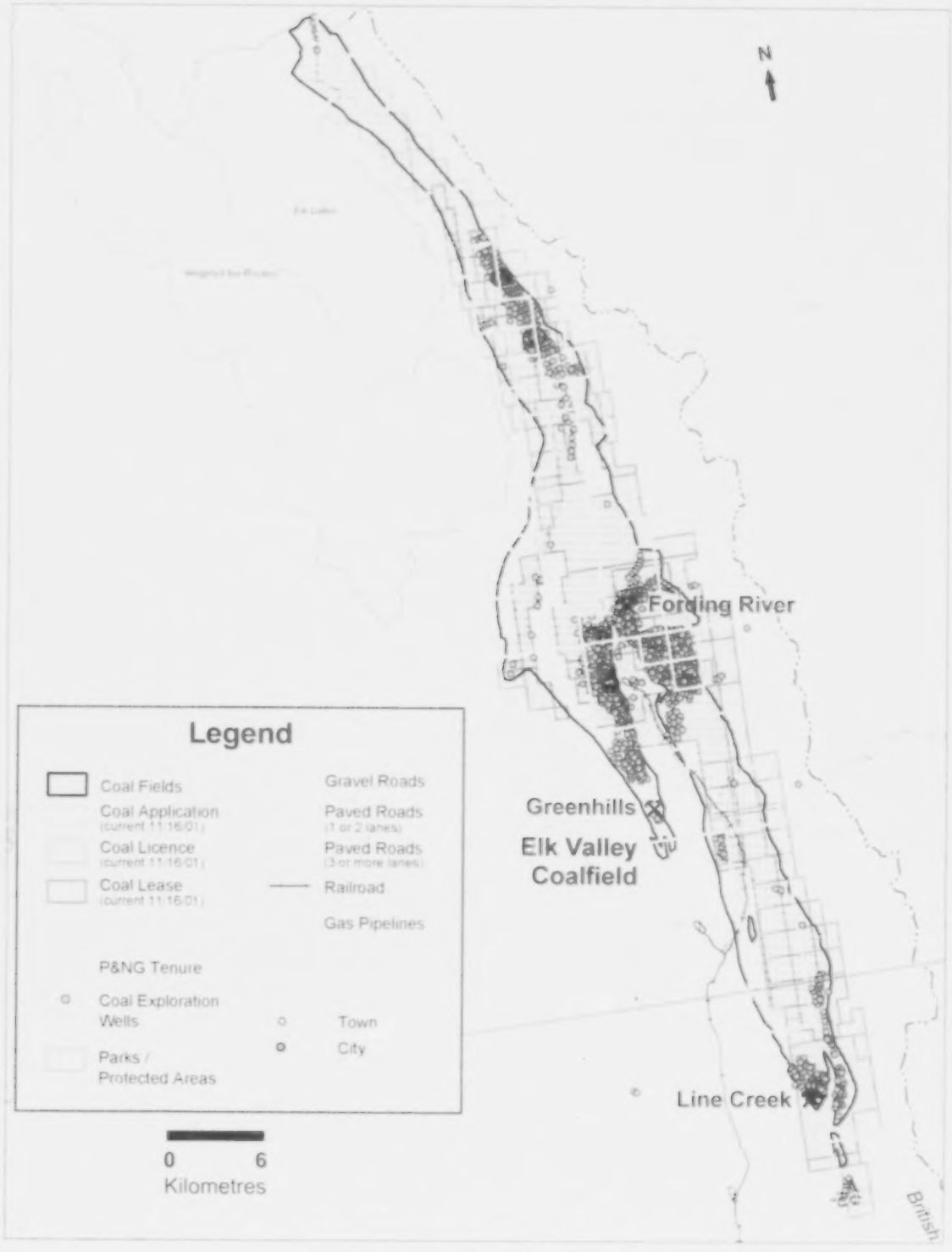



(Dawson, 1995)




Map of Elk Valley Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm




Map of Elk Valley Coalfield

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- In 1981, CANMET desorbed samples from three holes over a depth range of 0 to 400 metres (Feng et al., 1981). They found that seams above 200 metres contained less than 2 $cm^3/g$ of gas but below 200 metres gas contents ranged from 5 to 11 $cm^3/g$ (as-received basis).

- In 1991-92, Norcen drilled four holes and a limited production test well in the northern part of the Elk Valley Coalfield. The holes were located on the east limb of a syncline where the Mist Mountain Formation is 650 metres thick and contains nineteen seams with a cumulative thickness of 54 metres. Gas contents averaged 13.25 $cm^3/g$ (air-dried basis) for coals deeper than 250 metres. There were indications of moderate $CO_2$ contents in the gas desorbed from some samples.

- Suncor drilled a single hole in the core of the Alexander Creek Syncline south of the Greenhills mine in 1998. Some of the seams had high $CO_2$ concentrations and the company did not follow up on the exploration.

- Fording Coal Limited drilled a single hole on the mine site in 1993. This 533-metre deep hole intersected 44 cumulative metres of coal between 300 to 520 metres depth. Gas contents ranged from about 3 to 12.6 $cm^3/g$ on an air-dried basis, ash varied from 4 to 60 per cent. Generally, measurements indicated permeability in the range of 1 to 6 mD for the seams (Dawson et al., 2000).

- Since 2001, Encana has drilled seventeen holes in the Elk Valley Coalfield and is presently pumping on two pilots. Data will start to become public in 2004.

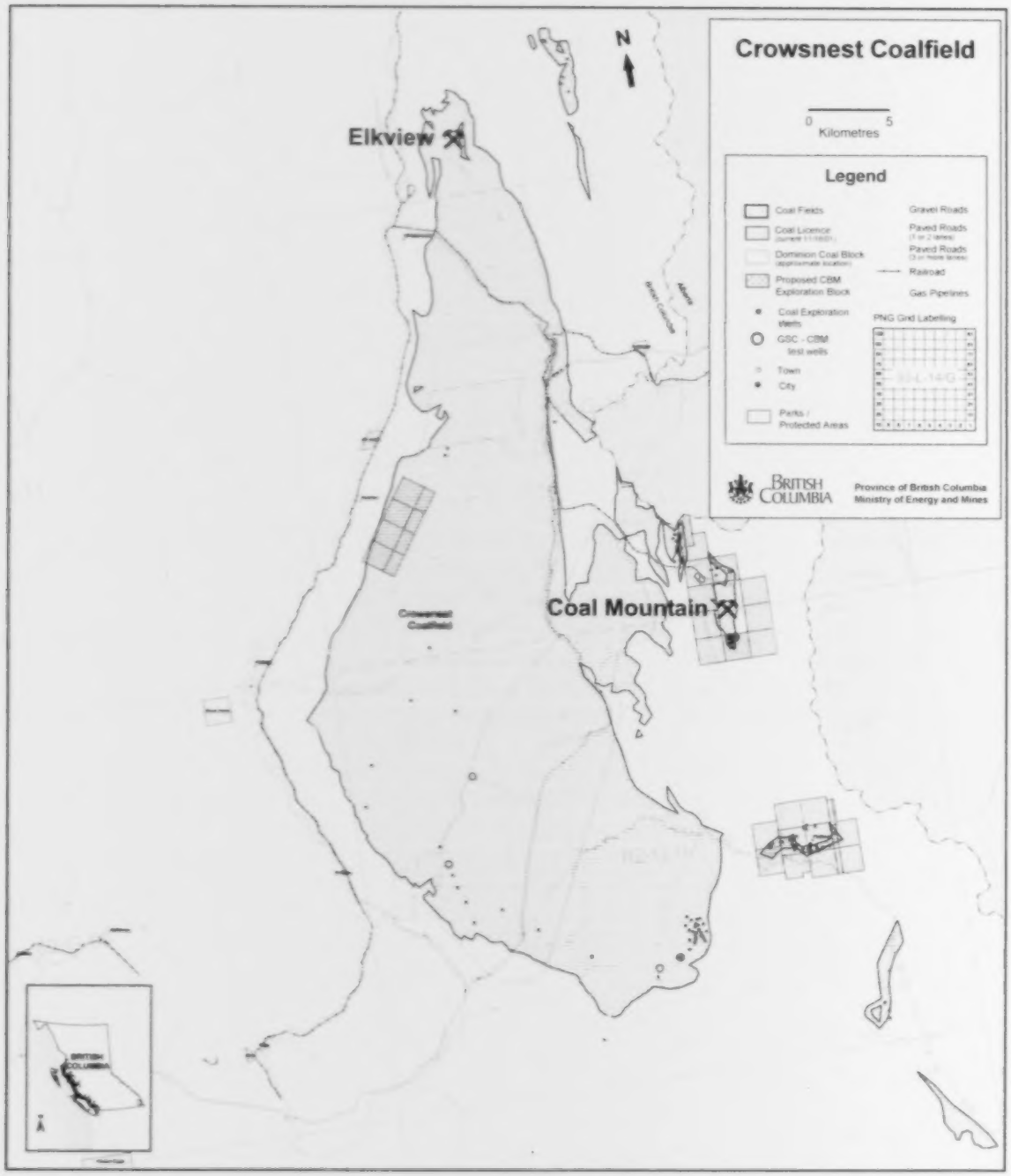
## Crowsnest Coalfield

### Coal

- The Crowsnest Coalfield has a coal resource of over 25 billion tonnes and includes the Elkview and Coal Mountain mines (Ryan, 2003). The coalfield extends from the town of Sparwood to 20 kilometres south of the town of Fernie. This 600 square kilometre area is underlain by the Jura-Cretaceous Mist Mountain Formation, which contains from 30 to 60 cumulative metres of high to low-volatile bituminous coal.

Typical Analyses Of The East Kootenay Coalfields

| Product coal dry basis | Medium-Volatile | High-Volatile |
|---|---|---|
| Volatile matter (%) | 21 - 28 | 32 |
| Fixed carbon (%) | 64 - 69 | 62 |
| Ash (%) | 8 - 9.8 | 6 |
| Sulfur (%) | 0.3 - 0.7 | 0.4 - 0.8 |
| Btu/lb | 13,750 - 14,200 | 14,200 - 15,050 |
| Mj/kg | 32 - 33 | 33 - 35 |
| Hardgrove Index | > 80 | >60 |
| Rmax% | 1.1 - 1.35 | 0.8 - 1.1 |




Map of Crowsnest Coalfield

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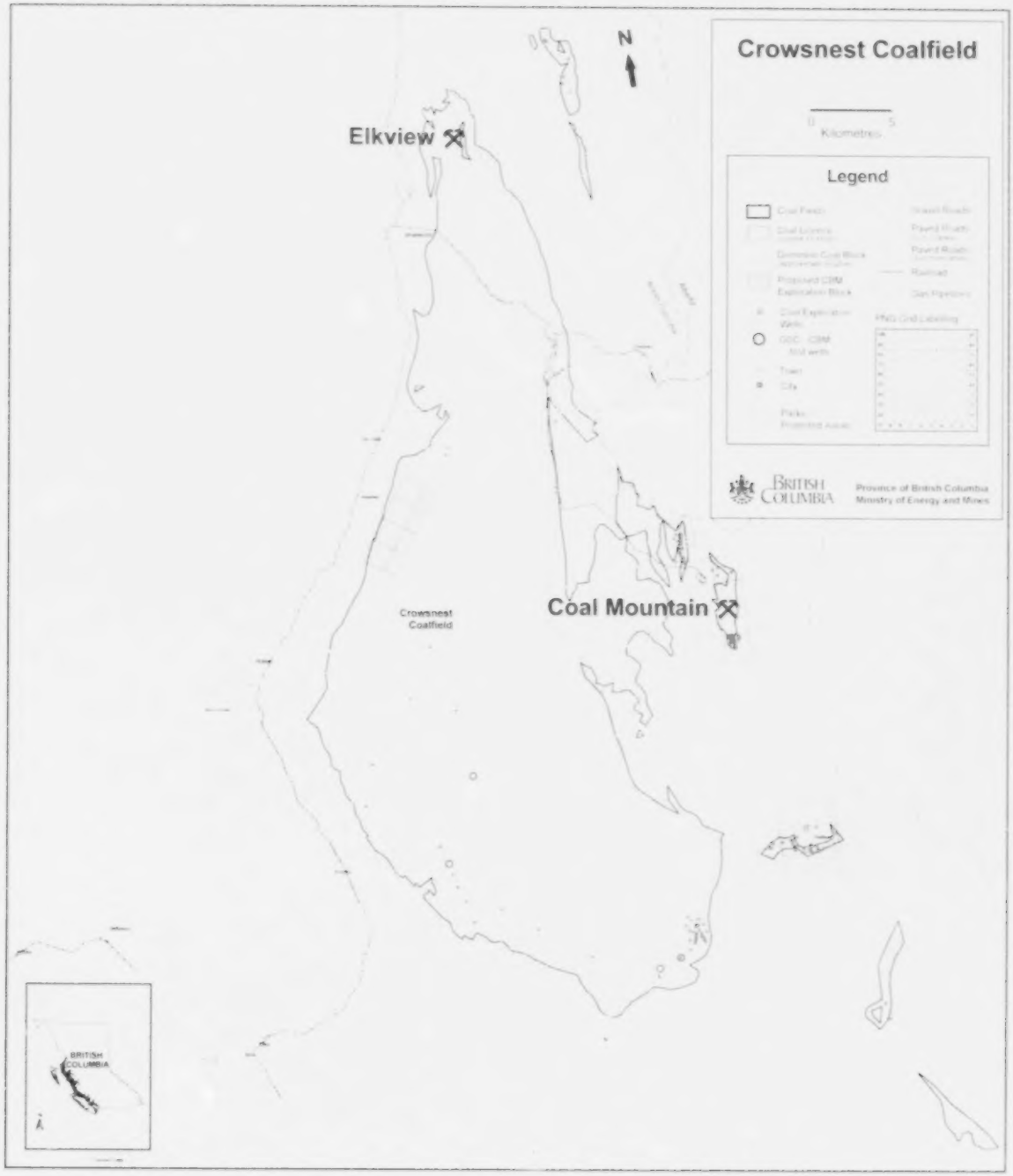


Map of Crowsnest Coalfield

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- The structure is a large basin cored by the younger Elk Formation and rimmed by the older Mist Mountain Formation. Coal rank varies around the perimeter of the coalfield and downdip into the basin.

- The Coal Mountain mine, located in an eastern outlier of the coalfield, produces high-volatile A bituminous weak coking coal; most of the coal comes from a single seam near the base of the Mist Mountain Formation. The Elkview mine, located in the northern end of the coalfield, produces medium-volatile hard coking coal, mainly from the bottom four seams in the formation.

### Coalbed Gas

- The Crowsnest Coalfield has a potential coalbed gas resource of over 6 Tcf (Ryan, 2003).

- In 1990-91, three companies drilled a total of seven holes in the field. These holes, drilled in the southern part of the coalfield, were drilled to test coal thicknesses and gas contents and did not test for production.

- Mobil/Chevron drilled two holes, one of which penetrated 491 metres of Mist Mountain Formation and intersected seven major coal zones with a cumulative coal thickness of 54 metres. Dawson et al. (2000) reported that the coal is fragmented or sheared. Gas contents ranged from 1.36 to 16.56 $cm^3/g$. Based on comparison of measured gas contents on a dry ash free basis to adsorption isotherm results, samples were saturated to between 25 and 63 per cent of maximum gas capacity. Permeability appeared to be low to moderate.

- Gulf Canada drilled two holes. Results were not encouraging mainly because the holes were drilled too close to coal subcrop. Saskoil drilled three holes. Two holes when combined intersected about 500 metres of the Mist Mountain Formation with about 63 metres of coal. The coal was moderately gassy with gas contents ranging from 0.4 to 11.9 $cm^3/g$ (air-dried basis).

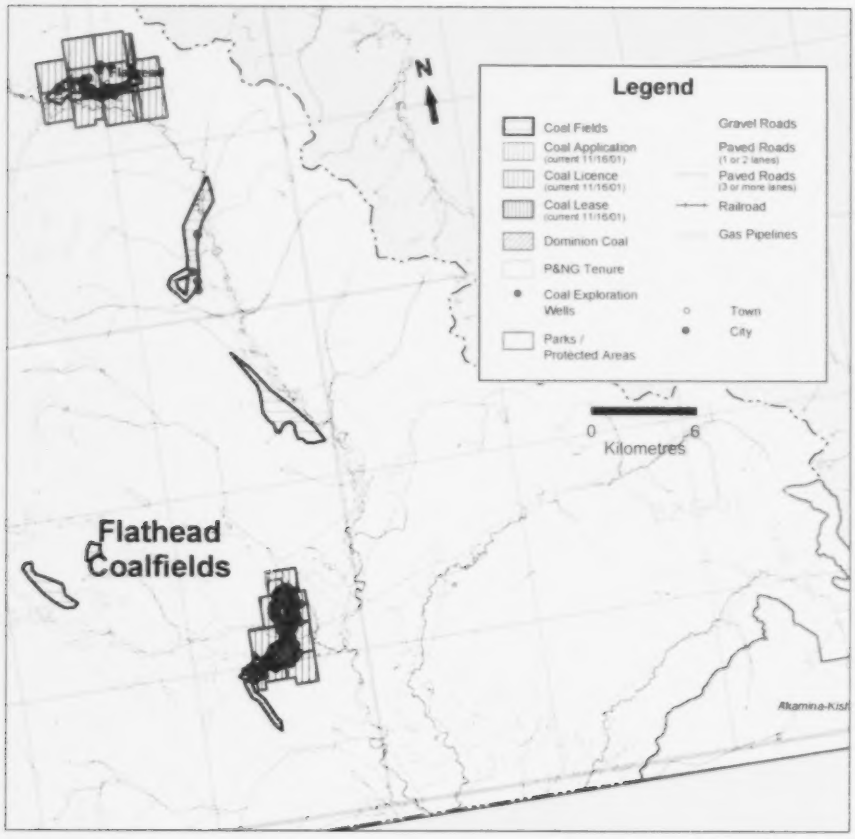
- Mobil/Chevron drilled three holes in 2003/2004. Data will remain confidential for 3 years.

## Flathead Coalfield

### Coal

- Coal occurs in a number of outliers of the Mist Mountain Formation, the largest of which is Sage Creek near the US border.

- The Mist Mountain Formation ranges from 198 to 259 metres in thickness; coal occurs in five horizons having an aggregate thickness of approximately 30 metres.




- The coal resource available for coalbed gas exploration in the Flathead Coalfield is about 1 billion tonnes (Ryan, 2003).

**Coalbed Gas**

- The coal resource available for coalbed gas exploration is about 1 billion tonnes with a potential coalbed gas resource of 0.4 Tcf (Ryan, 2003).

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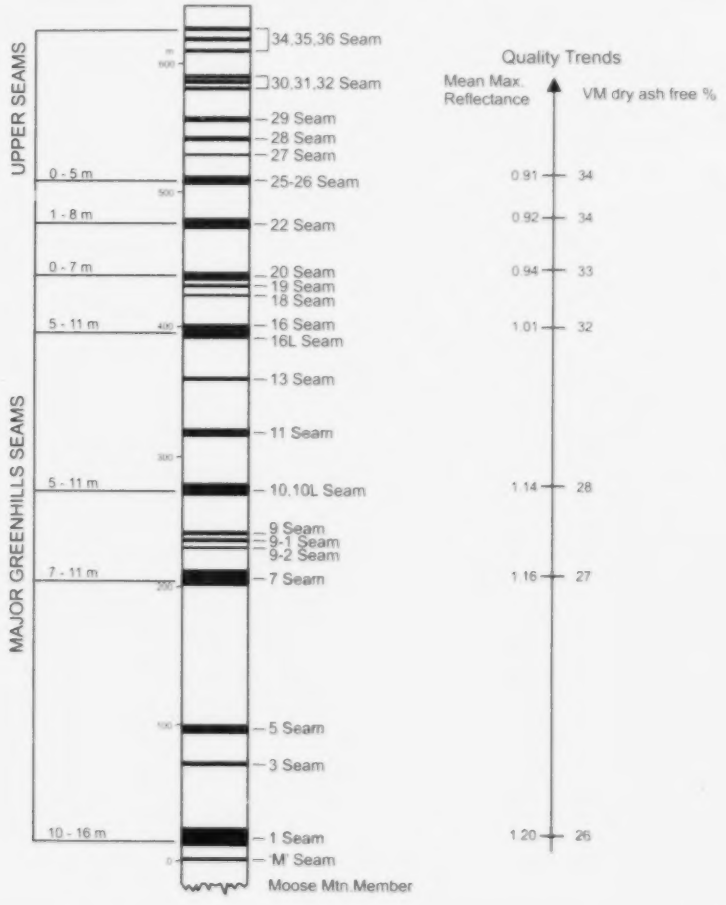
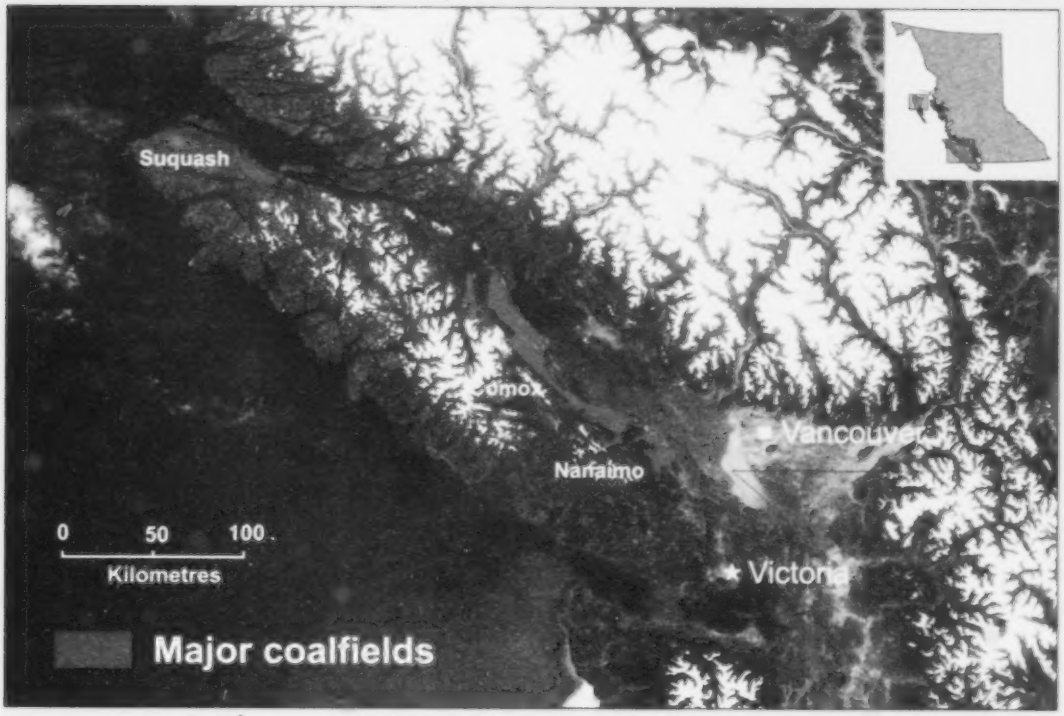



Stratigraphic column - Mist Mountain Formation, Greenhills mine, Elk Valley Coalfield (Dawson, 1995).

# Vancouver Island Coalfields

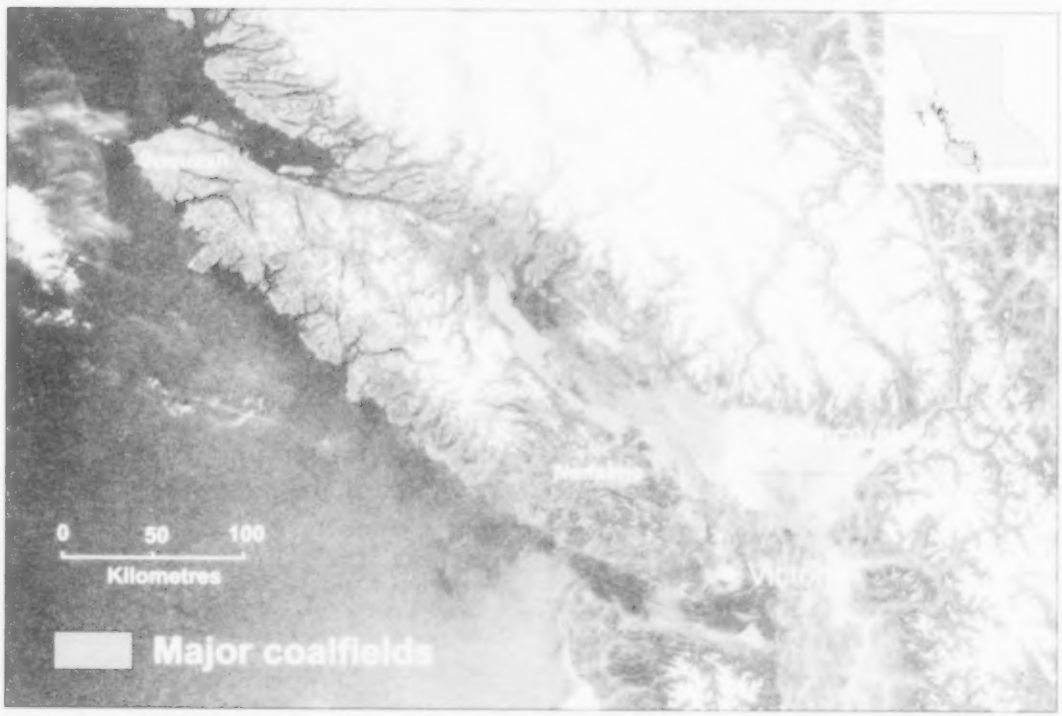



Along the coast of British Columbia coal deposits occur on Vancouver Island, the Queen Charlotte Islands to the north, and some of the Gulf Islands. Coal rank ranges from anthracite to lignite, with most being high-volatile bituminous. Host rocks range from Jurassic to Tertiary though most coal is found in the Upper Cretaceous Nanaimo Group. The major Upper Cretaceous coalfields on Vancouver Island are the Comox and Nanaimo fields. The Comox Coalfield includes the Quinsam underground mine, which is the only operating coal mine on the island. There are at least two coal-bearing formations within the Nanaimo Group. The first is the basal Comox Formation which is the source of coal in the Comox Coalfield, and the Extension and Protection formations in the Nanaimo Coalfield.

Estimates of the coal resources on Vancouver Island range from a low of 800 million tonnes to a high of 6920 million tonnes for an average of 3860 million tonnes.

The coalbed gas resource for Vancouver Island is estimated to be 0.3 to 1.6 Tcf. A gas pipeline passing through the Comox and Nanaimo coalfields enhance the development potential. There are a number of smaller coalfields with limited coalbed gas potential - these are the Suquash, Cowichan, Alberni, Qualicum and Quatsino coalfields. North of Vancouver Island, coal-bearing rocks on the Queen Charlotte Islands of Jura-Cretaceous and Tertiary ages have low coalbed gas potential.

# Vancouver Island Coalfields

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## Nanaimo Coalfield

### Coal

- The coalfield, which covers about 400 square kilometres, produced over 50 million tonnes of high-volatile A bituminous coal in the 100 years preceding 1953.

The producing area, in which the Douglas, Newcastle, and Wellington seams were mined, covered about 170 square kilometres. Air-dried basis analyses for the three seams is reported below.

| | Douglas | Wellington | Newcastle |
|---|---|---|---|
| Moisture (%) | 1.6 | 1.9 | 1.6 |
| Volatile matter (%) | 43.2 | 39.4 | 39.7 |
| Fixed carbon (%) | 45.5 | 45.7 | 47.7 |
| Ash (%) | 9.2 | 11.7 | 10.1 |
| Sulphur (%) | 1.2 | 1.3 | 0.9 |
| Btu/lb | 13,160 | 12,470 | 12,830 |
| Mj/kg | 30.61 | 29.01 | 29.84 |
| Hardgrove Index | 67 | 67 | 67 |
| FSI | ND | 3 - 4 | ND |
| Rmax% all seams | 0.64 - 0.72 | | |

(Ryan, 2002)

- Coal occurs in the Upper Cretaceous Extension and Protection formations, in three non-overlapping seams called the Douglas, Wellington and Newcastle. Remaining coal resources are estimated to range from 10 to 100 million tonnes (Ryan, 2003).

- Seams are broken by numerous normal faults which disrupt an easterly regional dip.

### Coalbed Gas

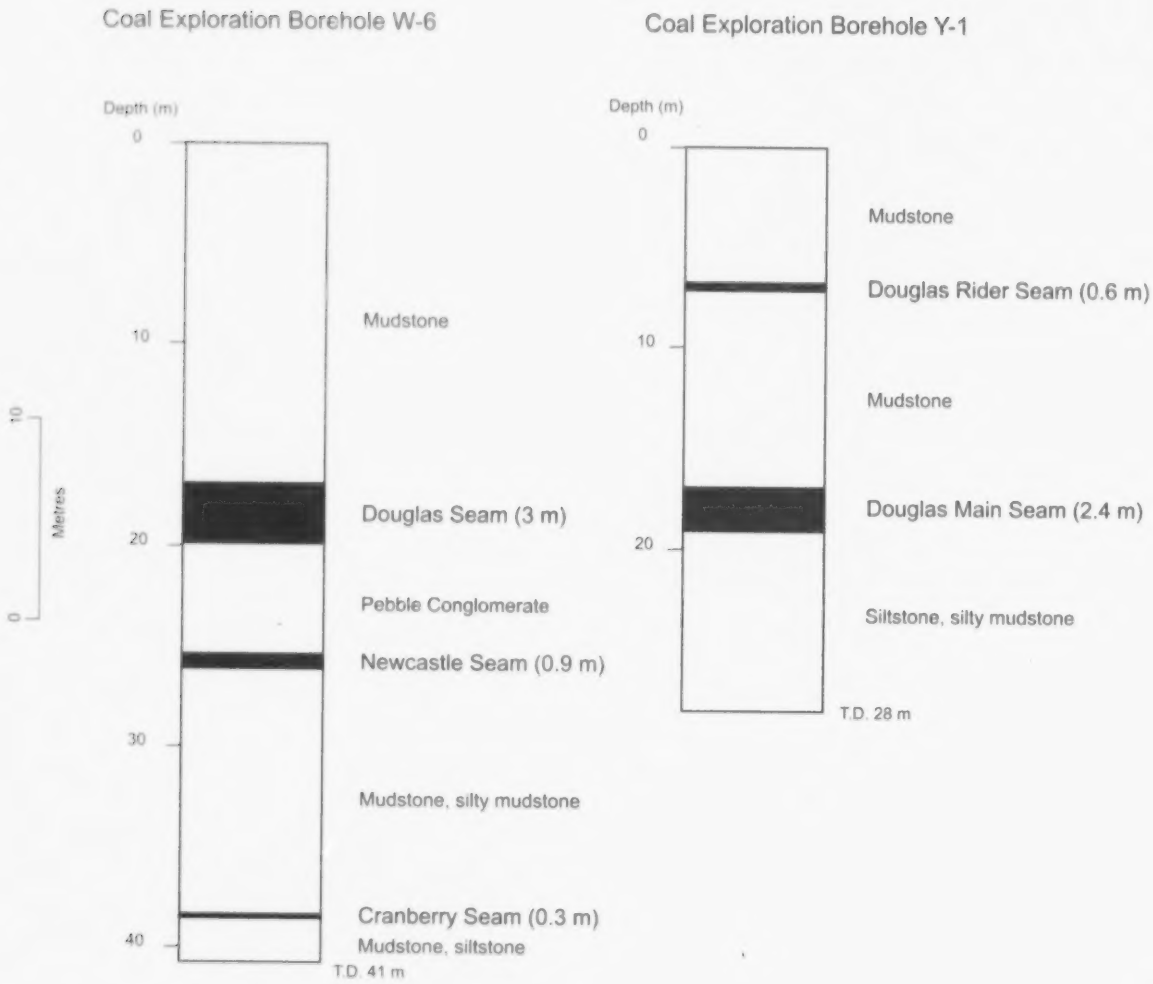
- Coalbed gas opportunities in the Nanaimo Coalfield are probably limited because of past underground mining of the Douglas and Wellington seams.

- Recent work indicates there is also coal in the Comox Formation within the Nanaimo Coalfield and there may be some coalbed gas potential in this deeper formation. Cumulative coal thickness in the Douglas coal zone ranges from 3 to 10 metres - a single intersection in the Comox Formation was 3 metres thick. Most of the coalbed gas potential will be in the eastward extension of the Douglas Seam and the deeper Comox coals if they are extensive.

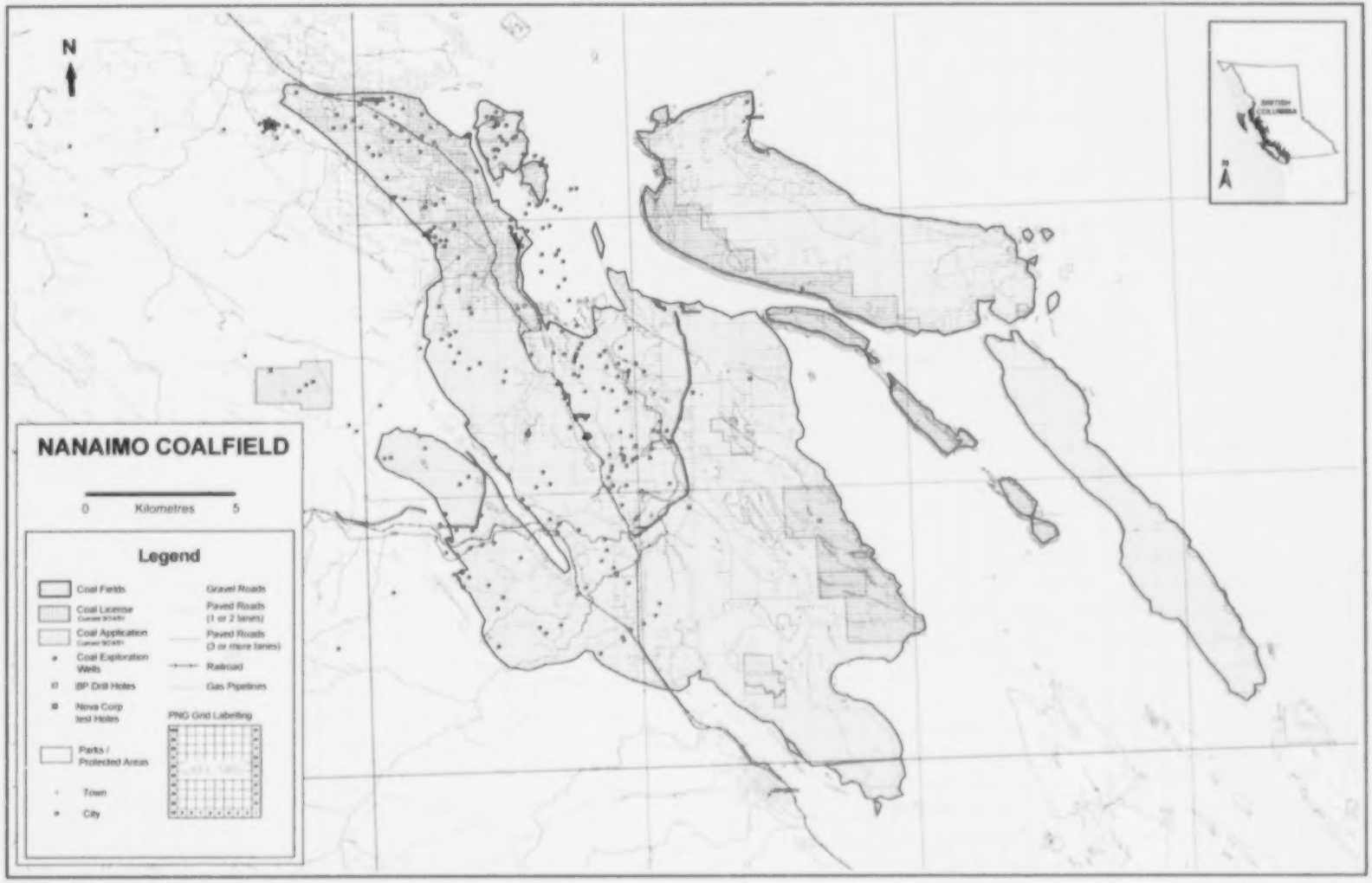
- A gas pipeline passes through the coalfield and enhances development potential.

- The potential coalbed gas resource of the Nanaimo Coalfield is estimated to be in the range of 0.4 Tcf (Ryan, 2003).

## Douglas Coal Zone, Nanaimo Coalfield




Representative stratigraphic column (Cathyl-Bickford, Wilson and Hoffman, 1992).




Map of Nanaimo Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Comox Coalfield

### Coal

- The coalfield covers an area of about 1100 square kilometres and produced 18 million tonnes of high-volatile A and B bituminous coal from 1888 to 1953.

| Typical Clean Coal Analysis On An Air-Dried Basis | |
|---|---|
| Moisture (%) | 3.0 |
| Volatile matter (%) | 36.5 |
| Fixed carbon (%) | 47 |
| Ash (%) | 13.5 |
| Sulphur (%) | 0.25 |
| Btu/lb | 11,880 |
| Mj/kg | 27.6 |
| Hardgrove Index | 48 |
| FSI | low |
| Rmax% | 0.6 - 0.88 |

(Ryan, 2002)

- Coal is found in the lowermost Comox Formation, which dips eastward with the regional dip complicated by broad folds, thrusts and normal faults; generally deformation is more intense along the western margin of the coalfield.

- The Comox Formation around the town of Courtenay contains four major seams with a cumulative thickness ranging from 2 to 8 metres.

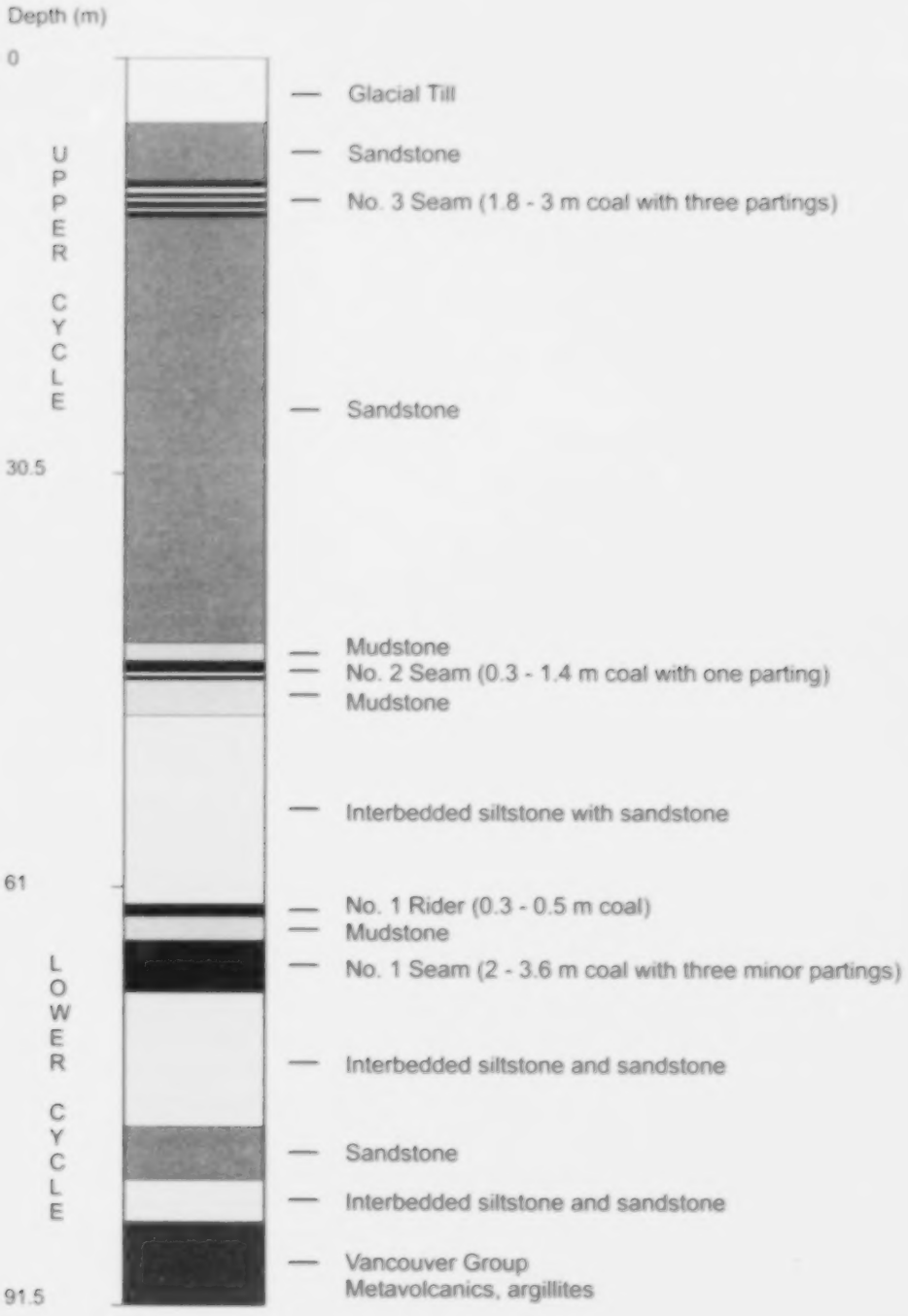
- The Comox Coalfield includes the Quinsam underground mine, which is the only operating coal mine on the island.

### Coalbed Gas

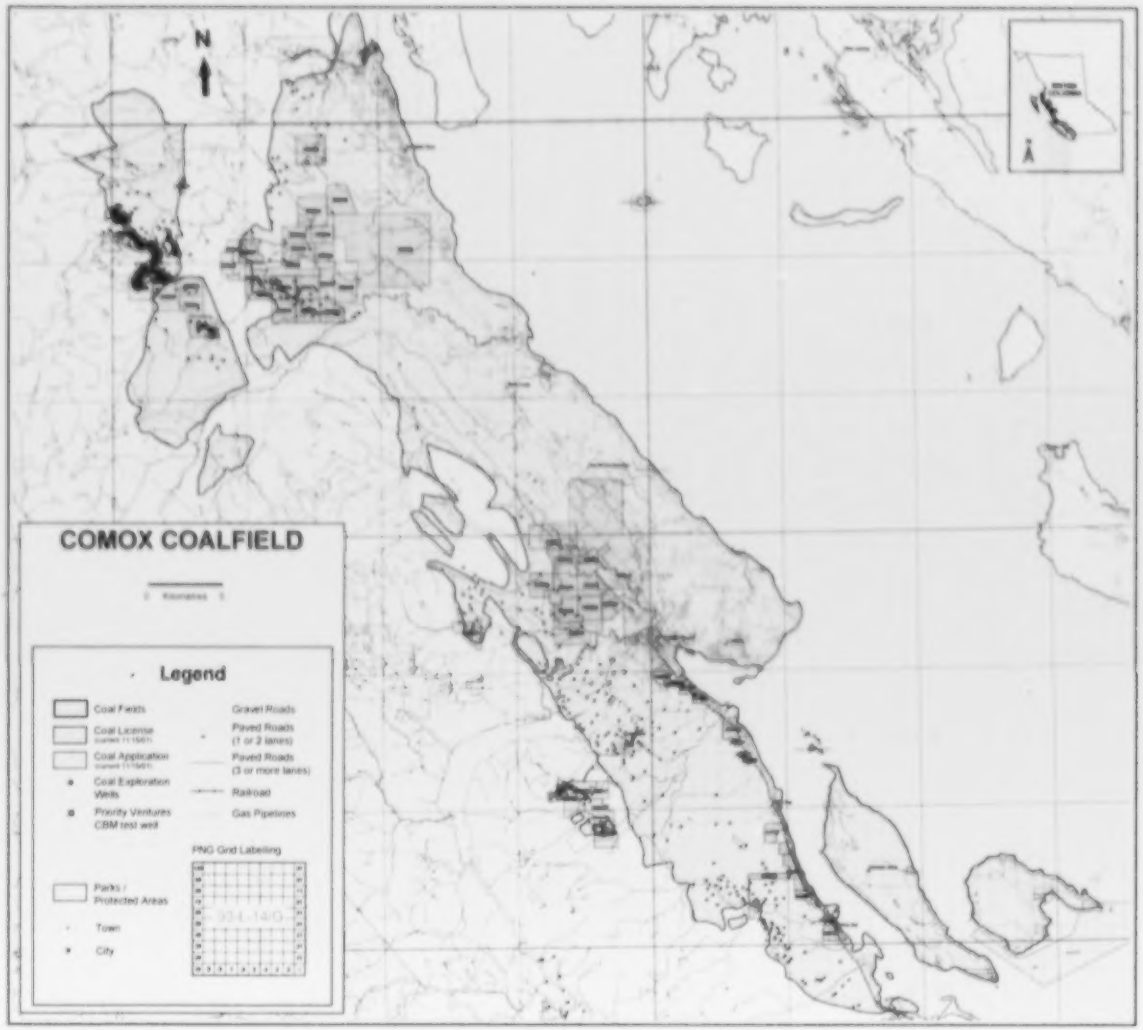
- The coalfield is divided into a number of sub-areas for the purposes of estimating coalbed gas resources. In the north, some desorption data was collected from holes drilled on the Quinsam mine site where the rank is high-volatile B bituminous and cumulative coal thickness is about 7.5 metres. Ryan and Dawson (1994) collected seven samples from two shallow holes - gas content of samples collected from depths ranging from 100 to 150 metres ranged from 0.44 to 1.632 $cm^3/g$ on a dry ash free basis. The sub-area covers an area of 155 square kilometres and is generally fault-bounded. The area of the coalfield around Campbell River is about 300 square kilometres and the potential coalbed gas resource is about 130 Bcf (Ryan, 2003).

- South of Campbell River and north of Courtenay, the coalfield covers an area of about 250 square kilometres, and has a potential coalbed gas resource of about 130 Bcf (Ryan, 2003). There has not been much surface exploration or drilling in this area and there is little information on coal thicknesses.

North End of Comox Coalfield

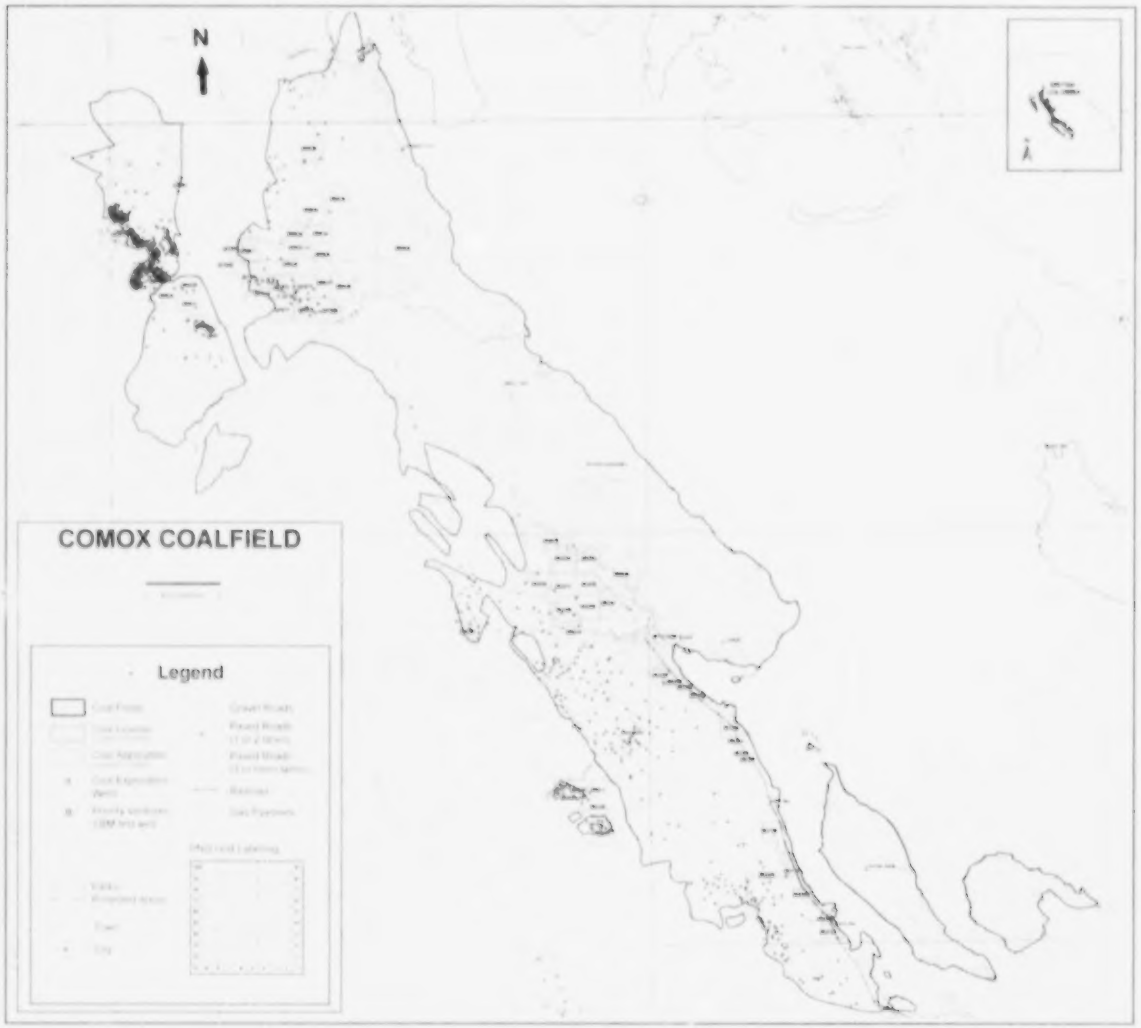



Representative stratigraphic column (Ronaghan, 1980).




Map of Comox Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm




Map of Comox Coalfield

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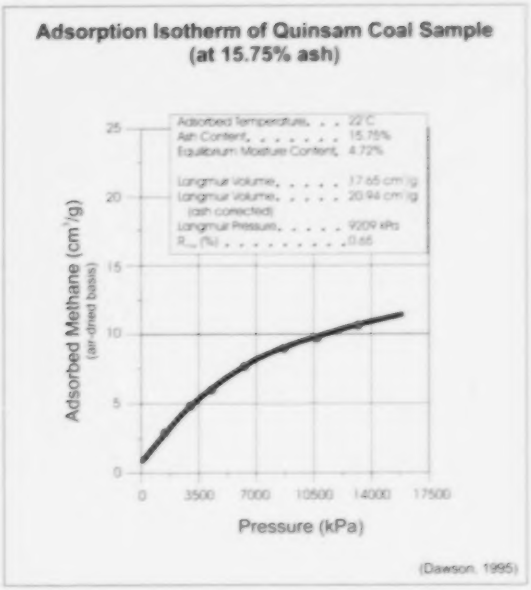



- The area of the Comox Coalfield around the town of Courtenay covers about 200 square kilometres. There is a history of mining in the area and gas emission data from the mines indicates gas contents ranging from 7.8 to 11.7 $cm^3/g$ on a dry ash free basis at depths that average 250 metres. The Comox Formation contains four major seams with a cumulative thickness ranging from 2 to 8 metres. Three coalbed gas exploration holes and a natural gas well were drilled in the Courtenay area in 2000 and 2001. Twelve samples for desorption were collected from the three coalbed gas holes and the results indicate gas contents ranging from 2.2 to 7.4 $cm^3/g$ on an as-received basis (or 3.6 to 12 $cm^3/g$ on a dry ash free basis) for samples collected over a depth range of 238 to 255 metres (Ryan, 2002).

- The area of the Comox Coalfield south of Courtenay covers about 330 square kilometres of which about 160 square kilometres is within the Tsable River area. Coal in the area, which has a rank of high-volatile A bituminous, is in the Comox Formation and cumulative coal thickness is about 8.3 metres contained in up to four seams. Gas was reported in a few deep holes drilled in the early 1900s. In 1996, 13 samples were desorbed covering depths from 126 to 376 metres. Gas contents on an as-received basis range from 1.6 to 5.5 $m^3$/tonne (Ryan, 1997). Gas contents increase consistently with depth but samples were under saturated. These concentrations are high enough to make the area attractive for its potential coalbed gas resource. Resource calculations for part of the southern end of the Comox Coalfield indicate a potential of about 0.45 Tcf (Ryan, 2003). A gas pipeline passes through the coalfield and enhances the development potential.

## Suquash Coalfield

### Coal

- The coalfield covers an area of 120 square kilometres of Nanaimo Group rocks.
- The coal-bearing section is at least 360 metres thick; coal is in the upper 200 metres of the section in approximately nine zones that contain about four metres of coal in total. Coal rank is high-volatile B to A bituminous.

| Quality On An Air-Dried Basis | |
|---|---|
| Moisture (%) | 6 |
| Volatile matter (%) | 23 |
| Fixed carbon (%) | 25.4 |
| Ash (%) | 45.3 |
| Sulphur (%) | 2.2 |
| Btu/lb | 11,580 |
| Mj/kg | 26.94 |
| Hardgrove Index | 43 |
| FSI | 1.5 |
| Rmax% | 0.63 - 0.81 |

(Ryan, 2002)

- If the coalfield is underlain by, on average, two metres of coal, then the coal resource would be about 300 million tonnes (Ryan, 2003). If the coal-bearing stratigraphy extends to the northeast under Malcolm Island, it provides an area of 300 square kilometres and a potentially larger coal resource.

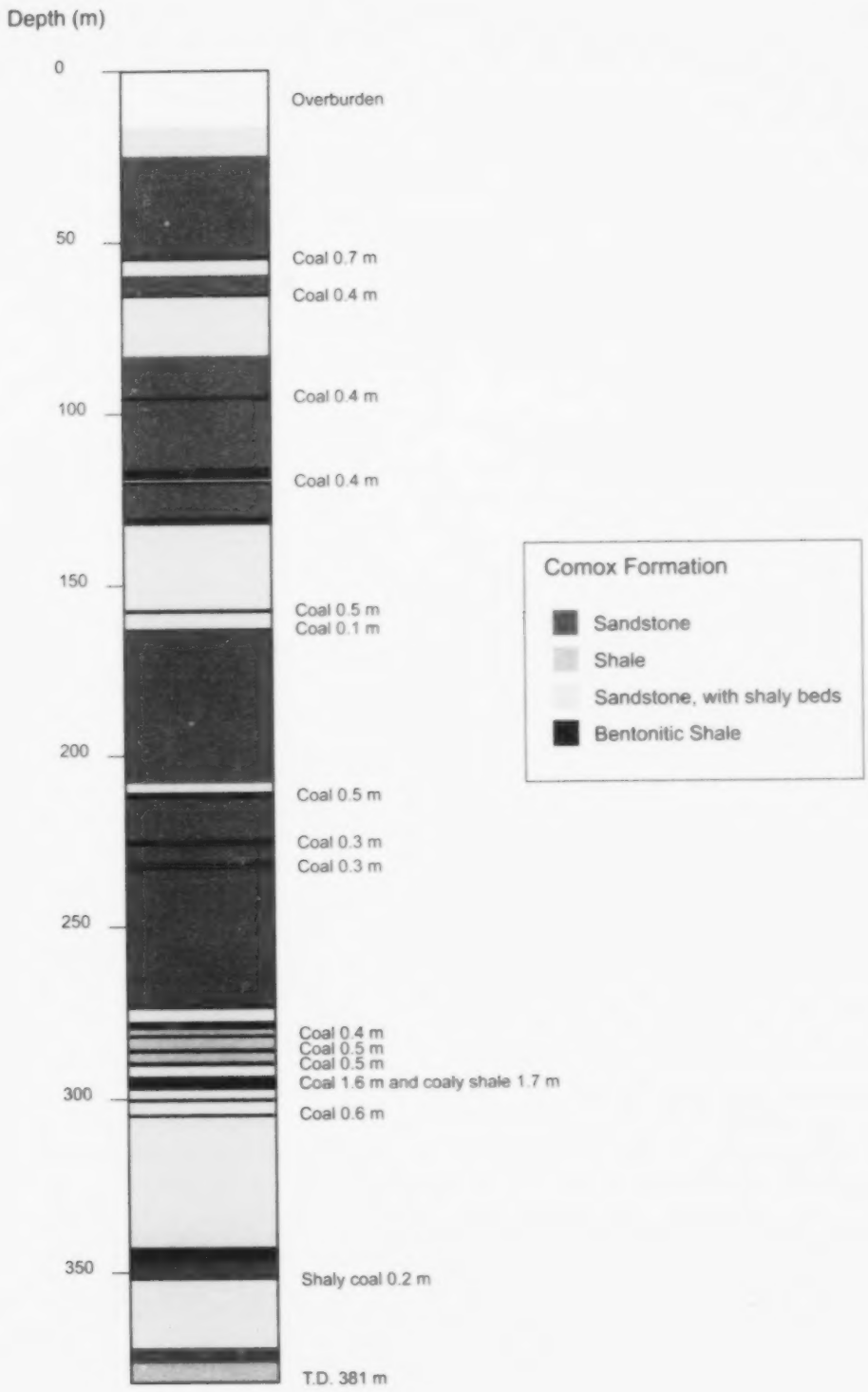
### Coalbed Gas

- If a coal resource of 300 million tonnes is assumed then the estimated potential coalbed gas resource is 45 Bcf (Ryan, 2003).

## Graham Island Coalfield

### Coal

- Coal deposits on the Queen Charlotte Islands have not been fully mapped because of thick vegetation, lack of outcrop and complex geology. All the deposits are on the larger northern Graham Island and are either Tertiary or Jura-Cretaceous.
- Preliminary exploration by a number of companies in recent years has failed to identify sufficient resources to justify continued development.
- Tertiary lignites are exposed in the northeast coastal areas and the older anthracites and bituminous deposits outcrop in the southwestern part of the island.




Representative stratigraphic column, Suquash Coalfield (Gardner, 1984).

The variation in rank of the older deposits is attributed to the presence of younger volcanic rocks in the area.

Typical Air-Dried Basis Analyses Of The Three Groups

| | Lignite | HV Bituminous | Anthracite |
|---|---|---|---|
| Moisture (%) | 18.5 | 1.2 | 1.8 |
| Volatile matter (%) | 44.2 | 36.2 | 4.7 |
| Fixed carbon (%) | 34.7 | 46.5 | 85.7 |
| Ash (%) | 2.3 | 16.1 | 6.6 |
| Sulphur (%) | 0.3 | 1.0 | 0.9 |
| Btu/lb | ND | 11,235 | |
| Mj/kg | ND | 26.13 | |

(Ryan, 2002)

**Coalbed Gas**

- The coal-bearing rocks generally have low coalbed gas potential.

## Key References (see Appendix I, References)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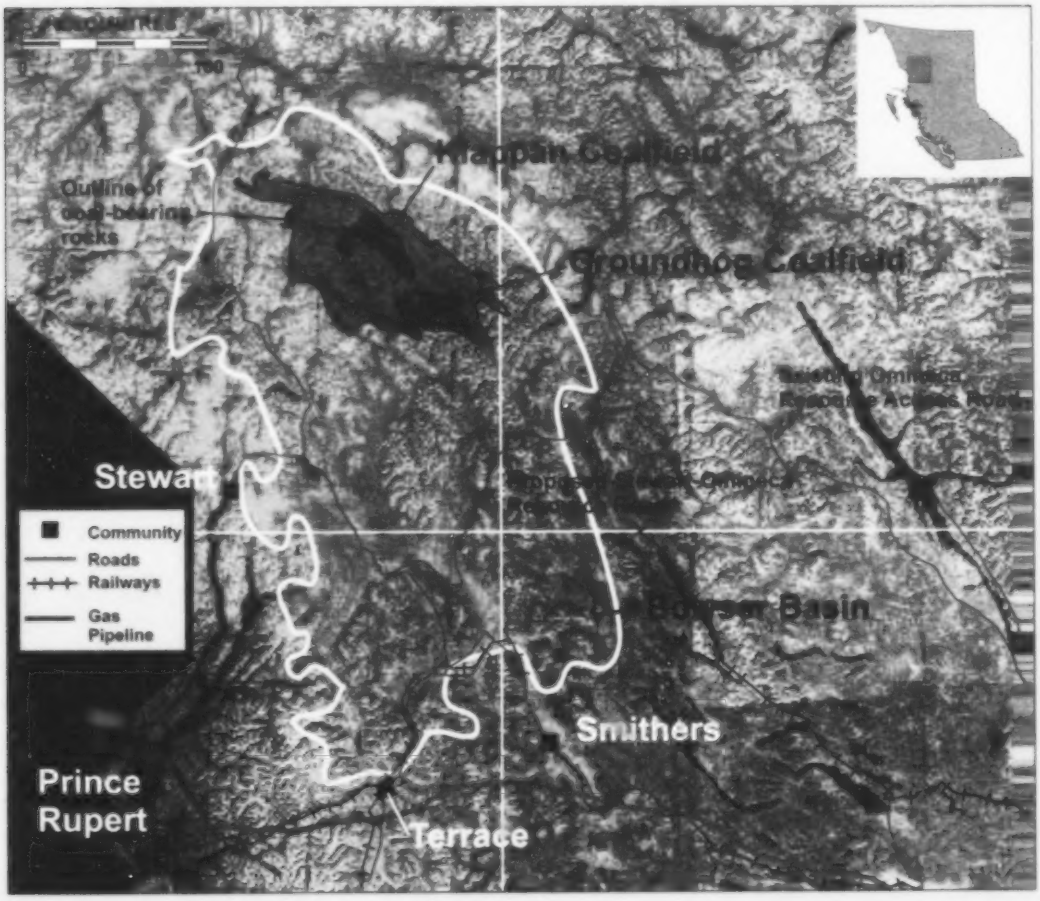
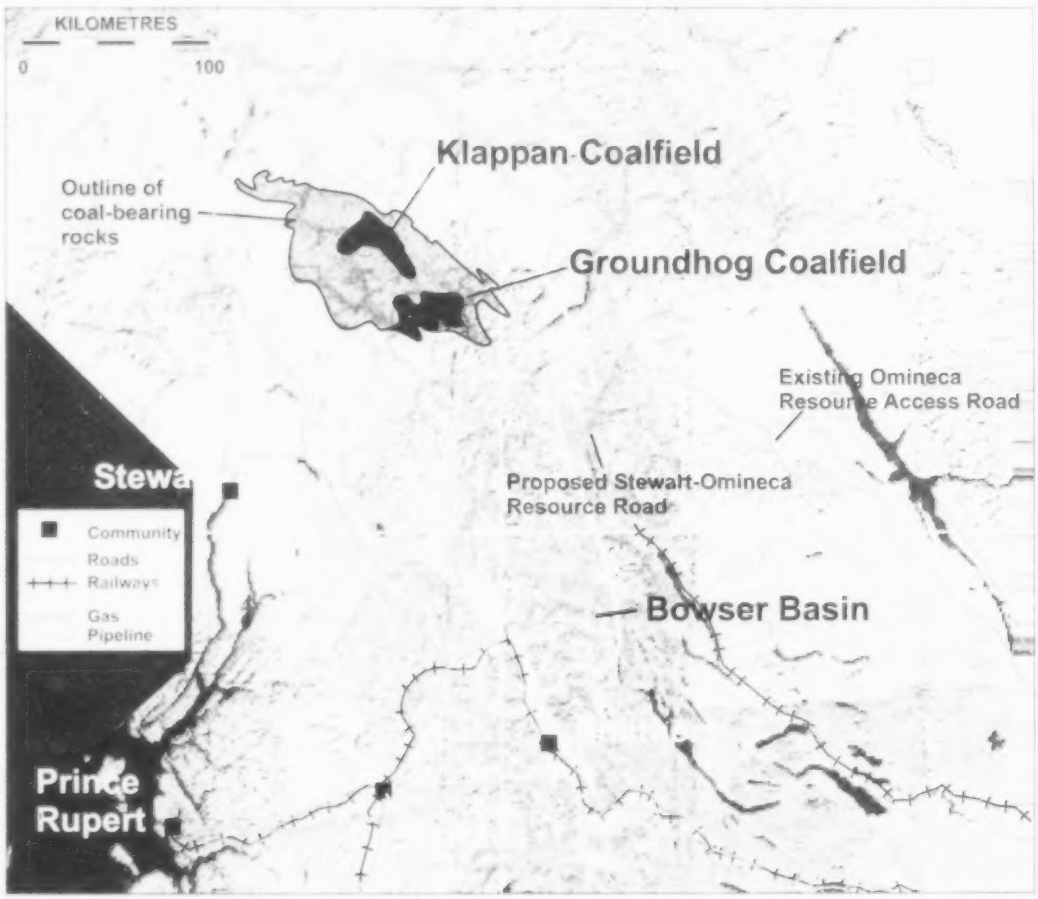
# Klappan and Groundhog Coalfields




Anthracite coal deposits of the Klappan and Groundhog coalfields occur within the Bowser Basin in a remote region of rugged mountainous terrain in northwestern British Columbia. The basin, which encompasses an area of approximately 50,000 square kilometres, is defined by the outcrop extent of up to 3500 metres of sediments of the Bowser Lake Group of Middle Jurassic to Lower Cretaceous age. The coal is contained in the Jura-Cretaceous Currier Formation which is up to 1100 metres thick and contains up to 25 seams, ranging in thickness up to 7 metres. The area is extensively folded with the regional structure dominated by a northwest trending synclinorium.

The Klappan Coalfield which is in the northern part of the Bowser Basin, was extensively explored in the period 1982 to 1986 with the hope of developing a major anthracite export mine. An estimated 37 million tonnes of anthracite is contained in the basin, primarily in the Klappan Coalfield. Though no coalbed gas wells have been drilled in the Bowser Basin, a potential of 8 Tcf of contained coalbed gas is conservatively estimated.

# Klappan and Groundhog Coalfields

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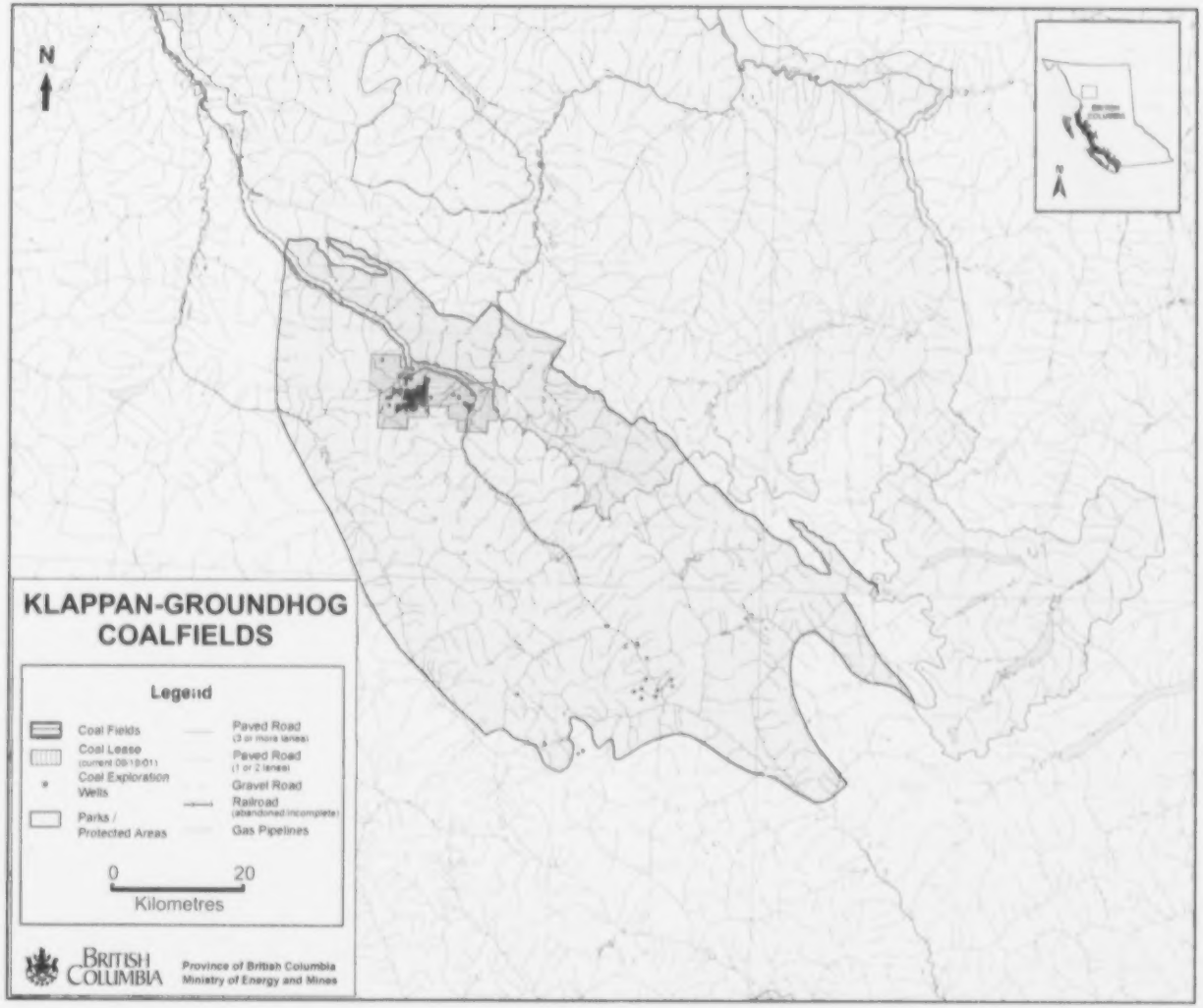



Map of Klappan-Groundhog Coalfields

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- Coal in the northern 10 per cent of the Bowser Basin is found in the Upper Jurassic to Lower Cretaceous Currier Formation in the Klappan Coalfield and in its equivalent in the south, the Prudential Formation in the Groundhog Coalfield.

- The Bowser sediments are extensively folded with the regional structure which is controlled by a prominent northwest trending synclinorium (the Biernes Synclinorium).

- Potentially economic coal seams up to 7 metres thick are present in the lower third of the Currier Formation. In the Mount Klappan area the formation is 900 to 950 metres thick and contains a cumulative coal thickness that ranges up to 54 metres.

- Coal-bearing rocks underlie approximately 2000 square kilometres around the synclinorium.

- The coal section is often folded into asymmetric chevron folds. The gently dipping limbs of these folds often represent undeformed structural domains on the order of 1 square kilometre.

- Coal rank ranges from semi-anthracite to meta-anthracite.

- The Klappan Coalfield was extensively explored in the period 1982 to 1986 by Gulf Canada Corporation with the hope of developing a major anthracite export mine. Fortune Minerals Limited acquired the property in 2002 and is reviewing development potential.

- The estimated potential coal resource in the Klappan and Groundhog coalfields is 37 billion tonnes and much of this is in the Currier Formation within the synclinorium (Ryan and Dawson, 1993).

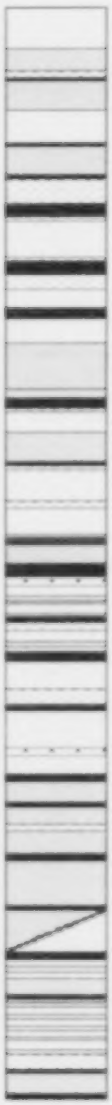
## Coalbed Gas

- An adsorption isotherm for a single sample of drill core coal indicates that the adsorption potential to a depth of about 1400 metres is high.

- The anthracitic rank coals are the best at retaining methane at shallow depth. The high rank has an important implication for improved permeability and gas recovery.

- An estimated potential coalbed gas of 8 Tcf is calculated using a conservative gas content value of 5 $cm^3/g$ (Ryan and Dawson, 1993). The resource assessment is restricted to the area underlain by the Currier Formation within the coalfields.

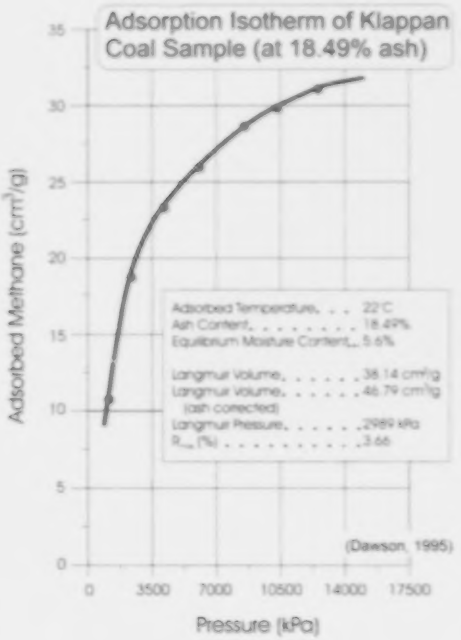
- Potentially economic locations for wells occur on the relatively undeformed flat-dipping limbs of asymmetric chevron folds.




Representative stratigraphic column of the Klappan coalfield; modified from Gulf Canada Limited information brochure, 1986.

| Raw | Clean Coal | Air-Dried Basis |
|---|---|---|
| Moisture (%) | 2.0 | 1.0 |
| Volatile matter (%) | 8.0 | 6.5 |
| Fixed carbon (%) | 54.0 | 85.5 |
| Ash (%) | 36.0 | 7.0 |
| Sulphur (%) | 0.5 | 0.5 |
| Btu/lb | 8,800 | 13,320 |
| Mj/kg | 20.47 | 31.0 |
| Hardgrove Index | | 38 |
| Rmax (%) | 2.8 - 4.4 | |

(Ryan, 2002)

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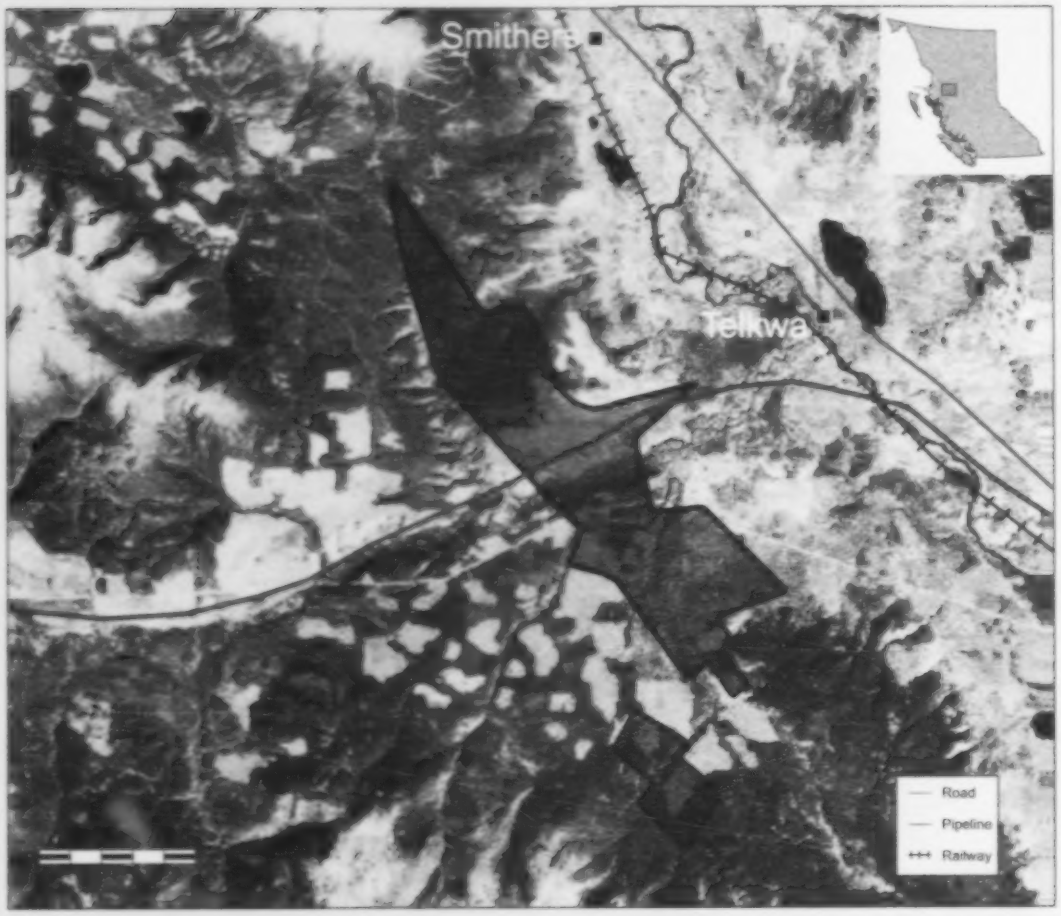
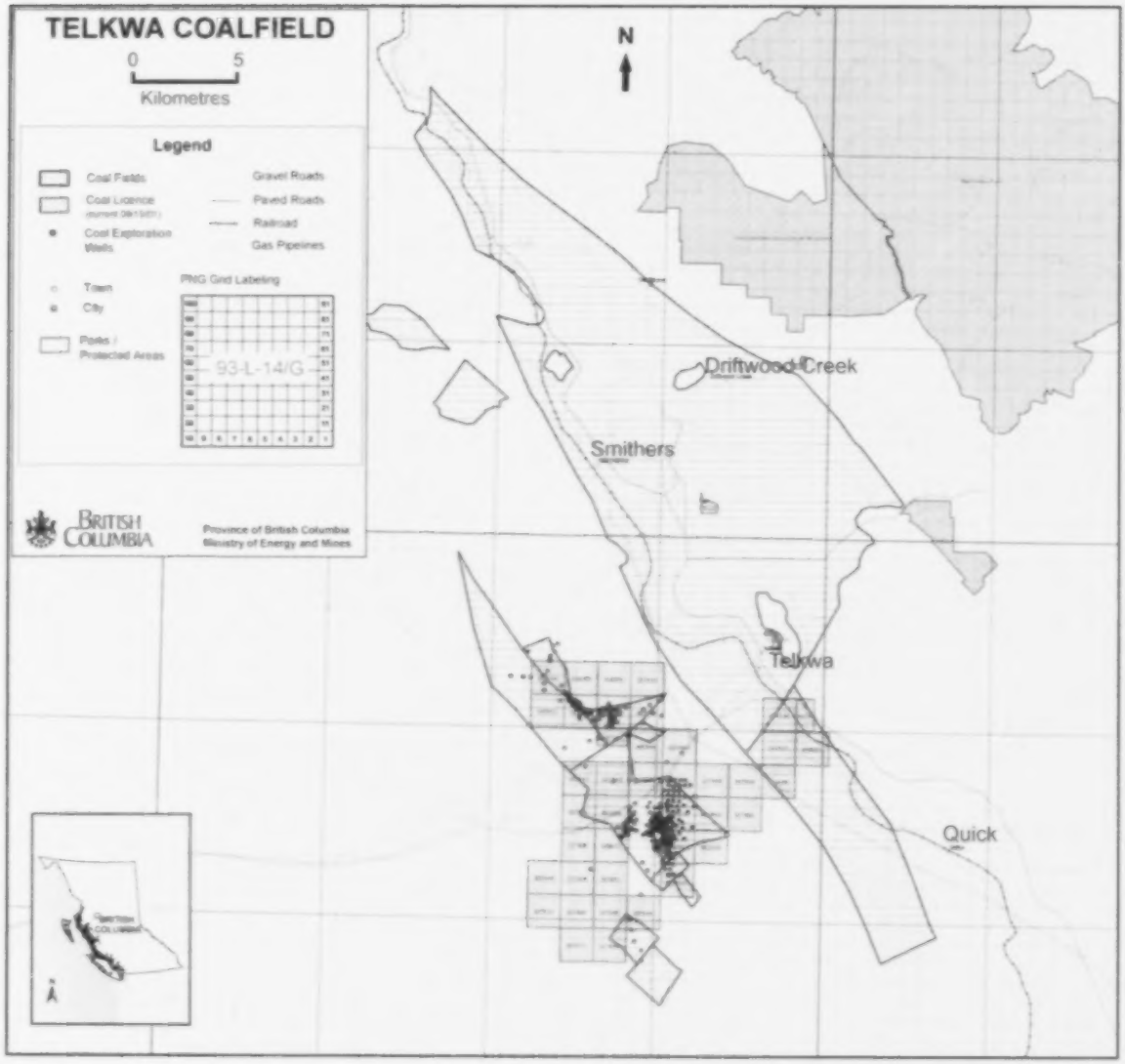
Ryan, B.D. (2003): A Summary of Coalbed Methane Potential in British Columbia; *Canadian Society of Exploration Geophysicists Recorder*, Vol.28, No.9, Nov. 2003, pages 32-40.

# Telkwa Coalfield




The Telkwa Coalfield in central British Columbia extends for about 50 kilometres along the Bulkley River from north of the town of Smithers to south of the village of Telkwa. Two coal-bearing units containing up to 21 metres of coal occur in the Lower Cretaceous Skeena Group. Thermal coal and small quantities of anthracite were mined in the coalfield in the early part of the century and more recently, near Telkwa, the coalfield has been intensively explored by a number of companies with the intention of developing an open-pit thermal-coal mine. A total surface mineable coal resource is estimated at 180 million tonnes and the potential resource available for coalbed gas is about 860 million tonnes.

A gas pipeline that connects Prince Rupert and Kitimat with pipelines from the northeast and southwest passes through the coalfield and is a significant infrastructure advantage. Desorption results indicate that coal in the coalfield retains gas at shallow depths. An estimate of the coalbed gas resource of the Telkwa Coalfield is 0.13 Tcf.




Map of Telkwa Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

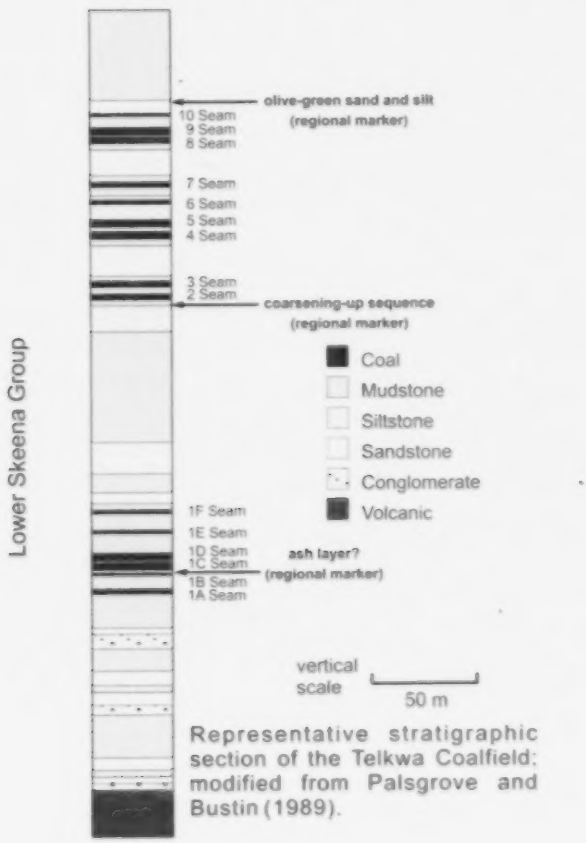
- Two coal-bearing units separated by a marine mudstone unit are contained in the Lower Cretaceous Skeena Group. The upper unit contains at least 8 seams with cumulative coal thickness up to 14 metres. The lower unit contains a single coal zone with cumulative coal thickness up to 7 metres. The seams are folded into open folds and broken by reverse and normal faults.

- Coal rank ranges from high-volatile bituminous A to anthracite, though most of the coal is in the range high-volatile A to medium-volatile bituminous.

- Close to 400,000 tonnes of thermal coal were produced from 1918 to 1980. Since 1978 there has been intensive exploration in the area culminating in plans to develop a 1 to 1.5 million tonnes per year open-pit thermal coal mine.

- The total surface mineable coal resource is estimated to be 180 million tonnes and south of Telkwa, 20 to 50 million tonnes have been identified as potentially surface mineable. The potential resource available for coalbed gas is about 860 million tonnes.

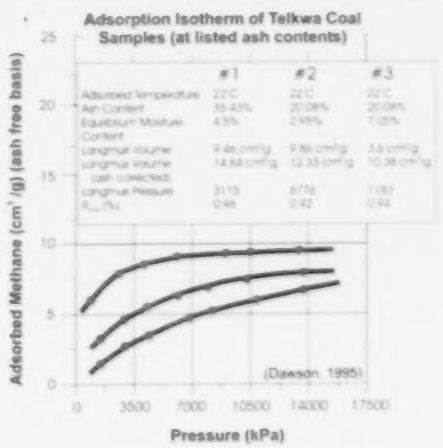
- The coalfield has historically been explored as a source of thermal coal but the wide range in rank means that there is potential for metallurgical coal.




Representative stratigraphic section of the Telkwa Coalfield; modified from Palsgrove and Bustin (1989).

| Estimated Shipped Quality | |
|---|---|
| Moisture (%) | 10 |
| Volatile matter (%) | 25.6 |
| Fixed carbon (%) | 65 |
| Ash (%) | 7.7 |
| Sulphur (%) | 1.0 |
| Btu/lb | 10,950 |
| Mj/kg | 25.6 |
| FSI | 0.0 - 5.5 |
| Hardgrove Index | 40 - 70 |
| Rmax% average | 1.0 |

(Ryan, 2002)



## Coalbed Gas

- Four samples collected over a depth range of 64 to 120 metres have gas contents that range from 3.75 to 4.49 $cm^3/g$ on a dry ash-free basis. Most of the samples appear to be saturated based on the results of adsorption isotherms (Ryan and Dawson, 1994).

- Three adsorption isotherms derived from core samples yielded an average Langmuir volume of approximately 12.5 $cm^3/g$ (ash free basis) (Dawson, 1995).

- Seams have moderate to good permeability and at depths ranging from 29 to 158 metres; values range from 0.5 to 50 milli Darcies (Ryan and Dawson, 1994).

- Interburden permeability is on average greater than that of the coal.

- Proximity to the Bulkley and Telkwa rivers suggest sufficient hydrostatic pressures exist to have retained significant volumes of gas at depth.

- A coalbed gas resource estimate for the Telkwa deposit is 0.13 Tcf (Ryan, 2003).

- A gas pipeline passes through the centre of the coalfield connecting the field to local or continental markets.

## Key References (see Appendix I, References)


Palsgrove, R.J. and Bustin, R.M. (1989): Stratigraphy and Sedimentology of the Lower Skeena Group, Telkwa Coalfield, Central British Columbia (93L/11); *in* Geological Fieldwork 1989, *B.C. Ministry of Energy ,Mines and Petroleum Resources*, Paper 1990-1, pages 449-454.

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Dawson, F.M. (1995): Coalbed Methane: A Comparison Between Canada and the United States; *Geological Survey of Canada*, Bulletin 489.

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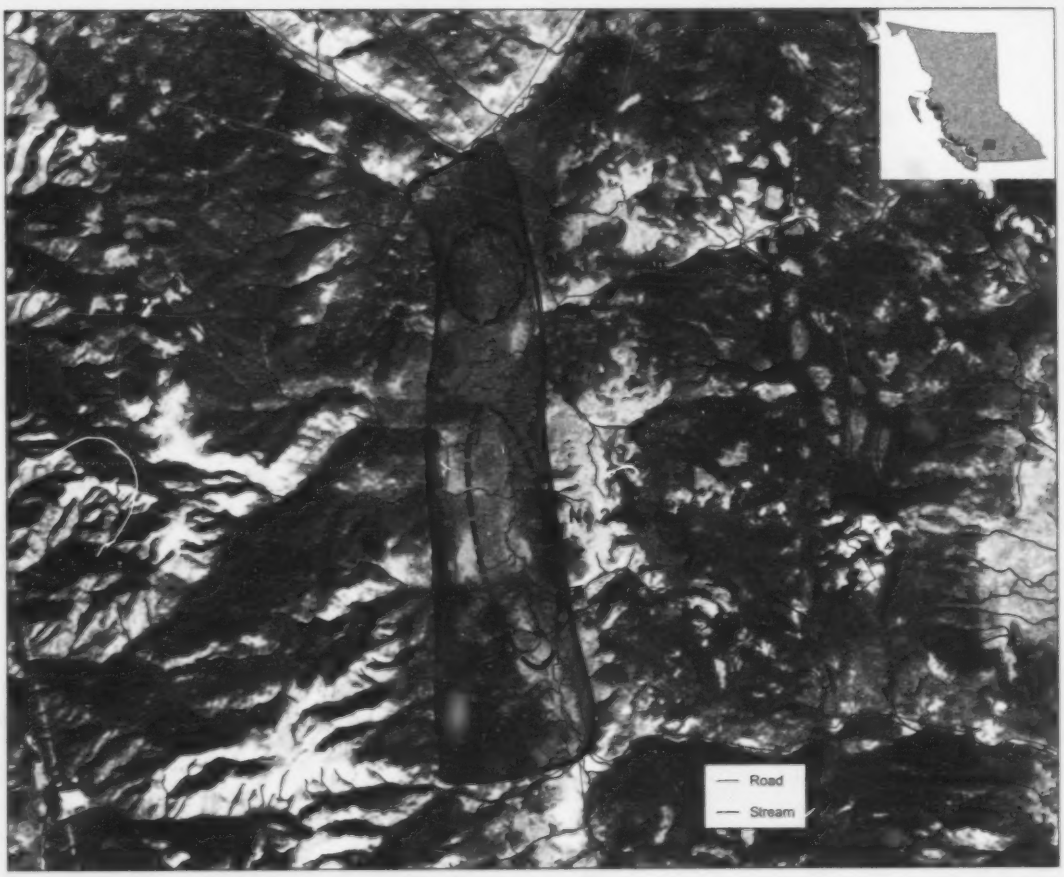
Ryan, B.D. (2003): A Summary of Coalbed Methane Potential in British Columbia; *Canadian Society of Exploration Geophysicists Recorder*, Vol.28, No.9, November 2003, pages 32-40.

# Hat Creek Coalfield

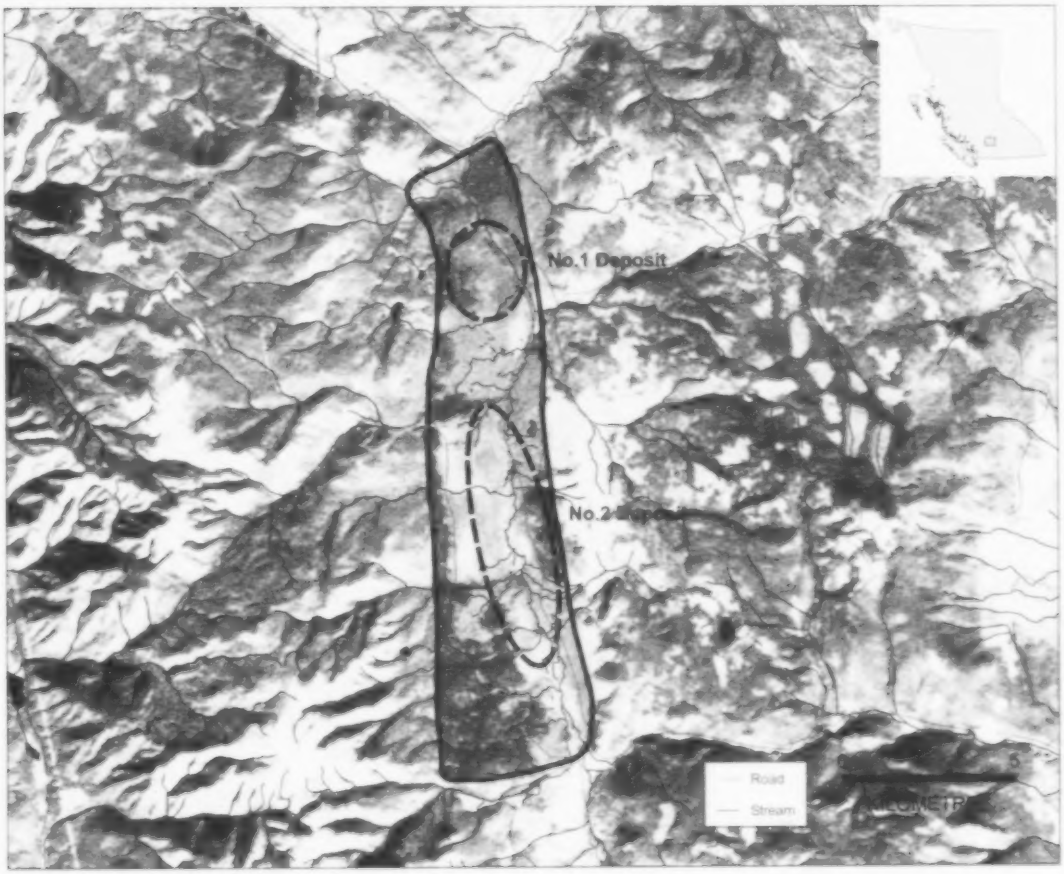



The Hat Creek Coalfield is located 20 kilometres west of Cache Creek in the south-central part of the province. The coalfield contains one of the thickest Tertiary coal deposits in the world with an enormous amount of low rank coal concentrated in a small area. It consists of two poorly exposed coal deposits. The northern, Number 1 deposit covers 3.5 square kilometres and the larger Number 2 deposit, 3 kilometres to the south, covers 25 square kilometres. The Number 1 deposit has been explored as a potential open-pit mine.

The Tertiary section in the area of the deposits is 1500 metres thick and is divided into three units. The middle Hat Creek Formation is about 500 metres thick of which about 65 per cent is coal. Estimates of the coal resource in the whole coalfield exceed 10 billion tonnes.

If gas contents are 1 to 3 $cm^3/g$, because of the large coal tonnages there could be a sizable coalbed gas resource of over 0.5 Tcf concentrated in a small area.

# Hat Creek Coalfield

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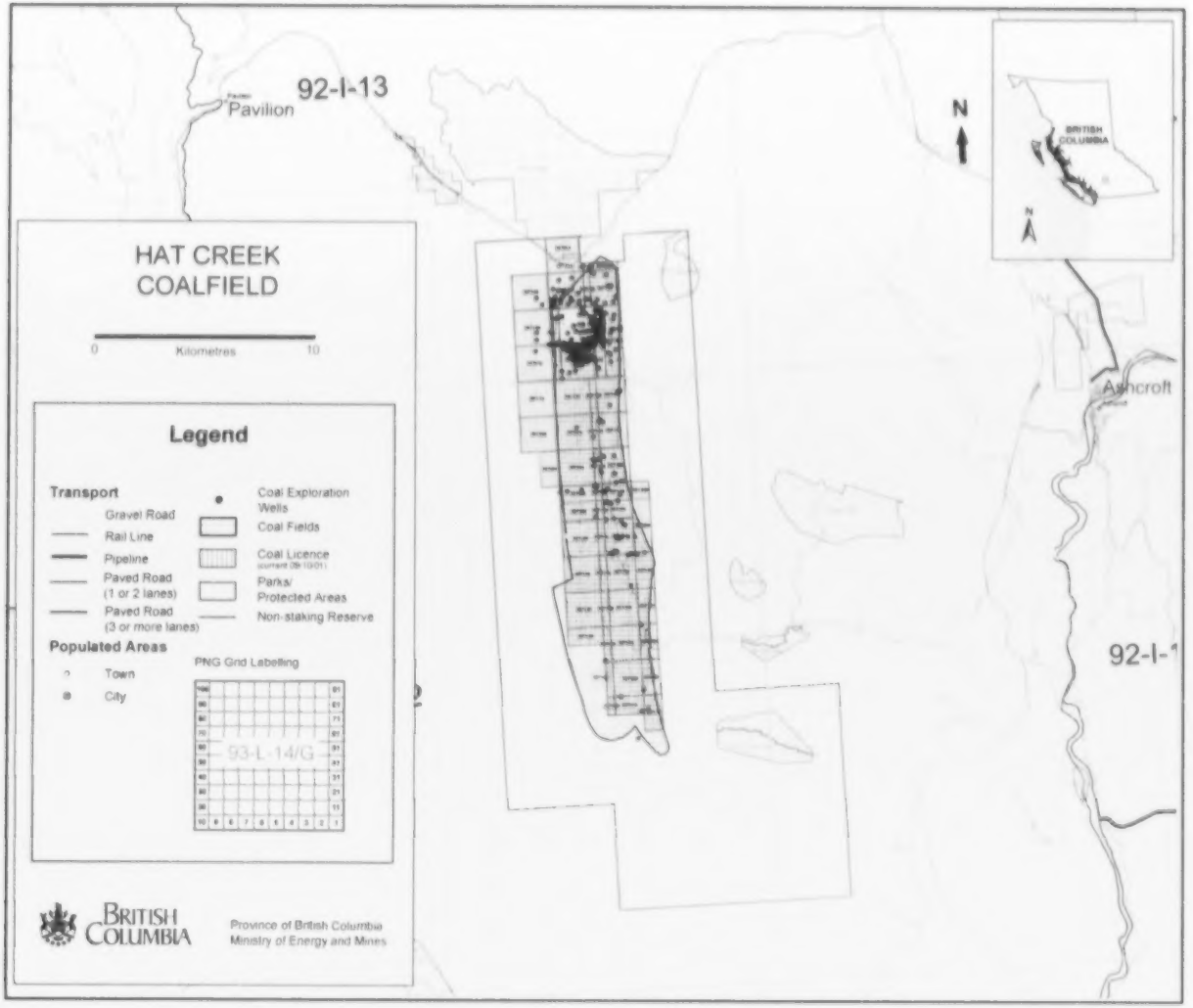



Map of Hat Creek Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- The Tertiary section in the area of the deposits is 1500 metres thick and is divided into three units. The middle Hat Creek Formation is about 500 metres thick of which about 65 per cent is coal.

- The Number 1 deposit has been explored as a potential open pit mine. Reserves in this deposit to a depth of 200 metres are over 500 million tonnes of lignite A to sub-bituminous C coal. The deposit comprises two south plunging half-synclines truncated on the southeast end by northeast trending gravity faults. Dips average about 25 degrees.

- The Number 2 deposit occurs within a graben that is bounded by north trending normal faults. The resource of the Number 2 deposit to a depth of 460 metres is estimated to be over 2 billion tonnes.

- Total resource in the basin is over 10 billion tonnes.

## Coalbed Gas

- The low rank of the coal means the amount of thermogenic methane generated will be small to nil and the ability of the coal to adsorb methane will also be low. However, low rank coals can have high meso-porosities compared to higher rank coals and therefore can retain moderate amounts of free gas, much of which would likely be of biogenic origin.

- Even if gas contents are only of 1 to 3 $cm^3/g$ because of the large coal tonnages (over 10 billion tonnes) there could still be a sizable coalbed gas resource at Hat Creek of over 0.5 Tcf concentrated in a small area (Ryan, 2003).

## Key References (see Appendix I, References)


Bustin, R.M. (1999): Free Gas Storage in Matrix Porosity: A Potentially Significant Coalbed Resource in Low Rank Coals; in Proceedings International Coalbed Methane Symposium 1999, May 3-7th, *University of Alabama*, pages 197-214.

Church, B.N. (1977): Geology of the Hat Creek Coal Basin; in Geology in British Columbia 1975, *B.C. Ministry of Energy, Mines and Petroleum Resources*, pages 99-118.

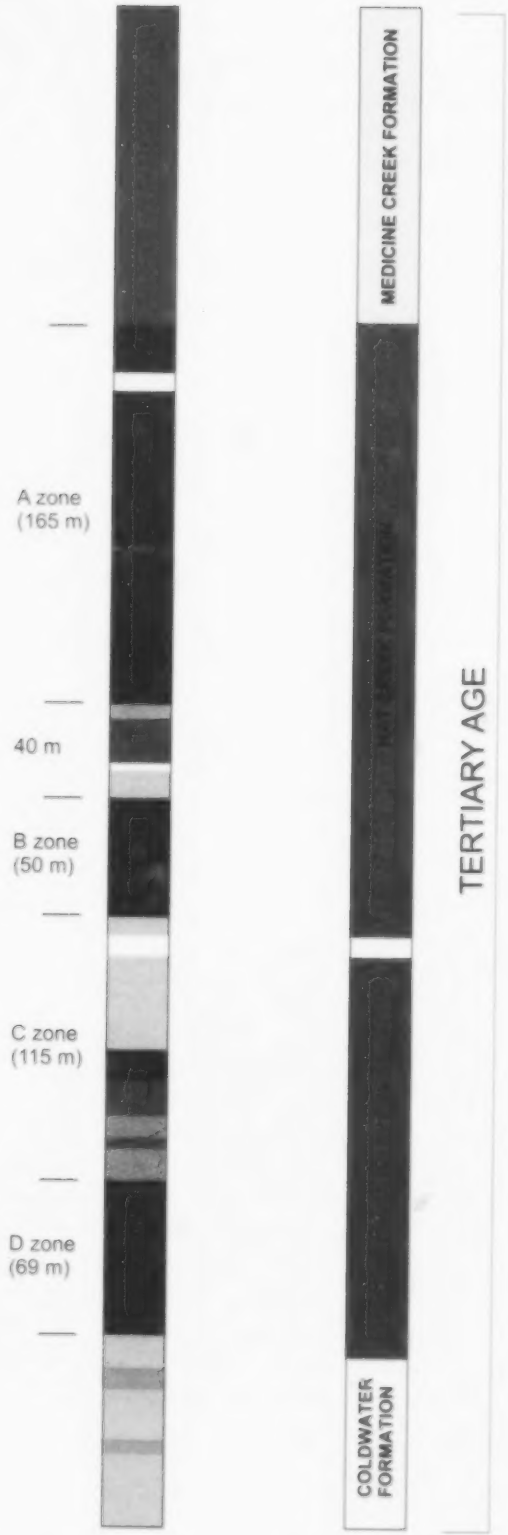
Ryan, B.D. (2003): A Summary of Coalbed Methane Potential in British Columbia; *Canadian Society of Exploration Geophysicists Recorder*, Vol.28, No.9, November 2003, pages 32-40.

Ryan, B.D. (2003): Overview of the Coalbed Methane Potential of Tertiary Coal Basins in the Interior of British Columbia; in Geological Fieldwork 2002, *B.C. Ministry of Energy and Mines*, Paper 2003-1, pages 213-236.

COAL MEASURES

Total thickness - 445 metres
Net coal thickness - 286 metres

- Claystone
- Coal
- Sandstone
- Conglomerate
- Siltstone
- Carbonaceous claystone



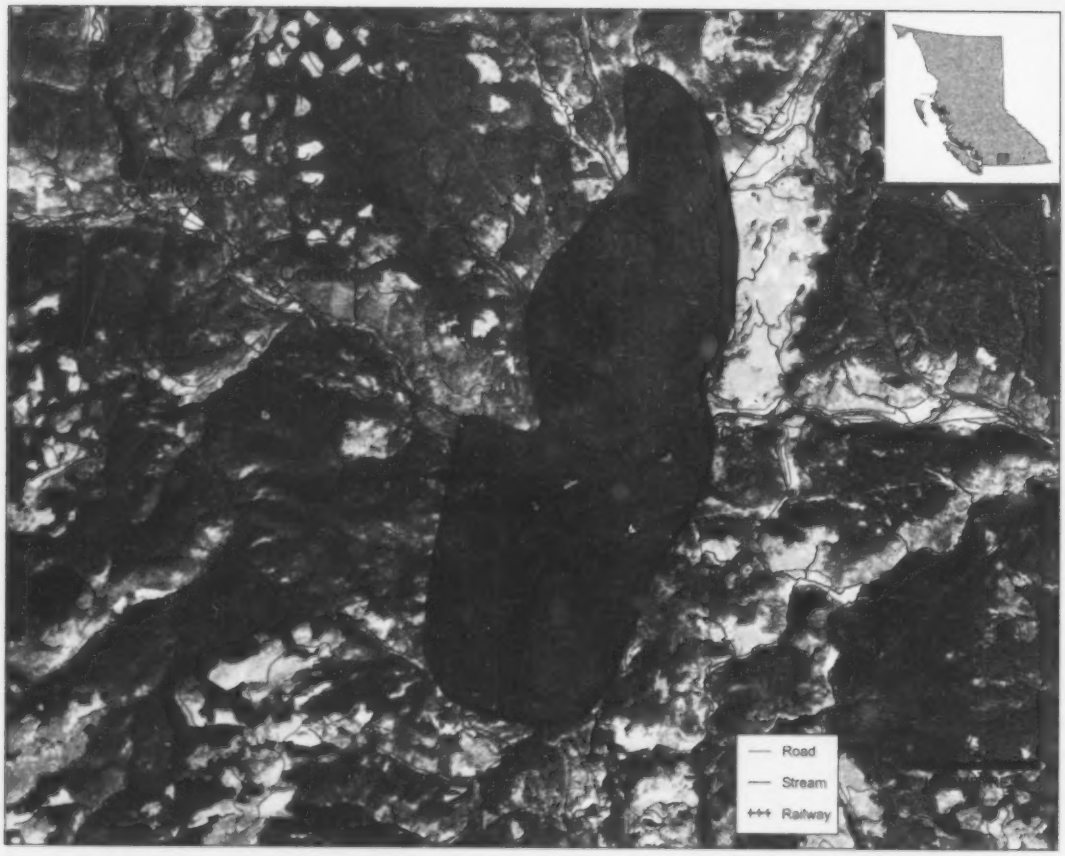

Typical Raw As-Received Coal Quality

| | |
|---|---|
| Moisture (%) | 23.5 |
| Volatile matter (%) | 24.8 |
| Fixed carbon (%) | 25.1 |
| Ash (%) | 26.6 |
| Sulphur (%) | 0.2 - 0.7 |
| Btu/lb | 5800 |
| Mj/kg | 13.49 |
| Hardgrove Index | 58 |
| Rmax% | 0.4 |

(Ryan, 2002)

Representative stratigraphic column, Hat Creek Deposit (Suncor CBM Prospectus, 2000).

# Princeton Coalfield




The Tertiary Princeton Coalfield is located in the south-central part of the province and is centred on the town of Princeton. It covers an area of about 170 square kilometres and is approximately 24 kilometres long and 4 to 7 kilometres wide. The coalfield is composed of a number of northwest trending synclines with faults defining the western and eastern edges. There were thirteen small underground mines and one on surface that operated in the central part of the coalfield up until about 1961. From 1919-40, about 2.1 million tonnes of coal were produced.

In the area south of Princeton there are four major coal zones, numbered from one at the top to four at the base of about 530 metres of the coal-bearing Allenby Formation. Most of the coal resource, which is high-volatile B bituminous in rank, occurs near the middle of the formation within the southern half of the coalfield, south of the town of Princeton. There is at least a 110 million tonne coal resource.

Based on work to date, Petrobank estimates that the potential gas-in-place resource is 250-500 Bcf.

Typical Raw As-Received Coal Quality

| | |
|---|---|
| Moisture (%) | 23.5 |
| Volatile matter (%) | 24.8 |
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| Ash (%) | 26.6 |
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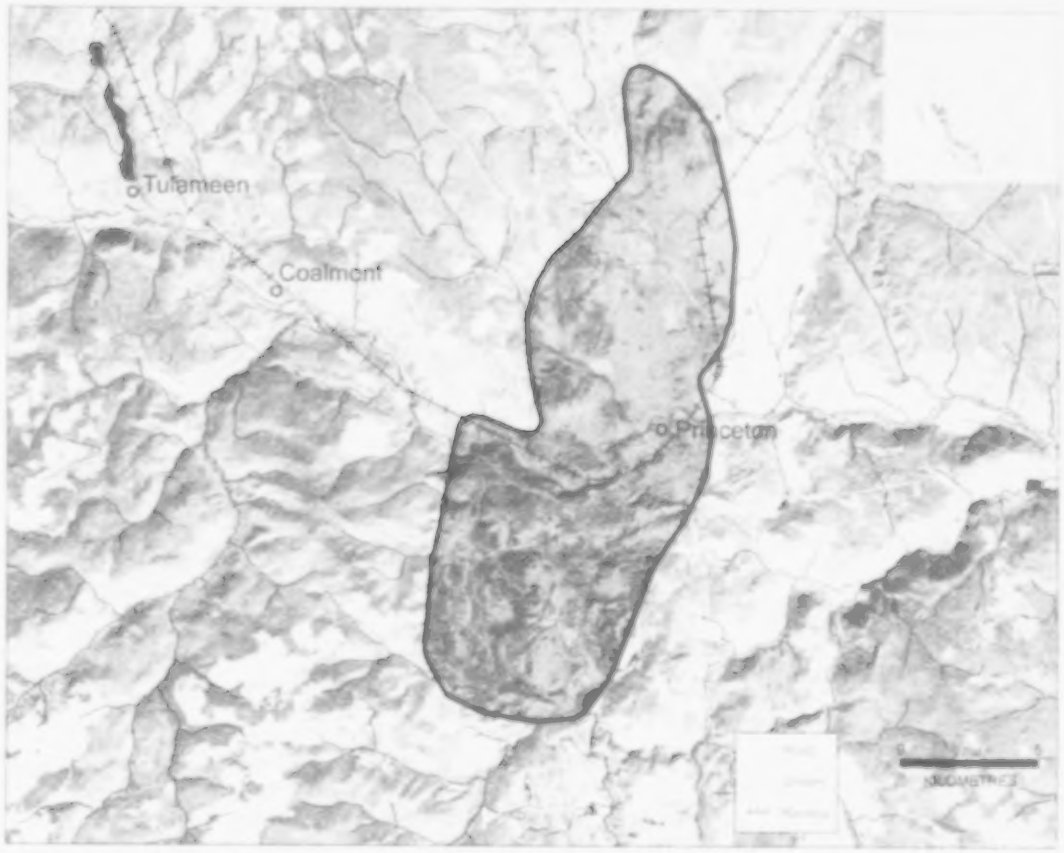


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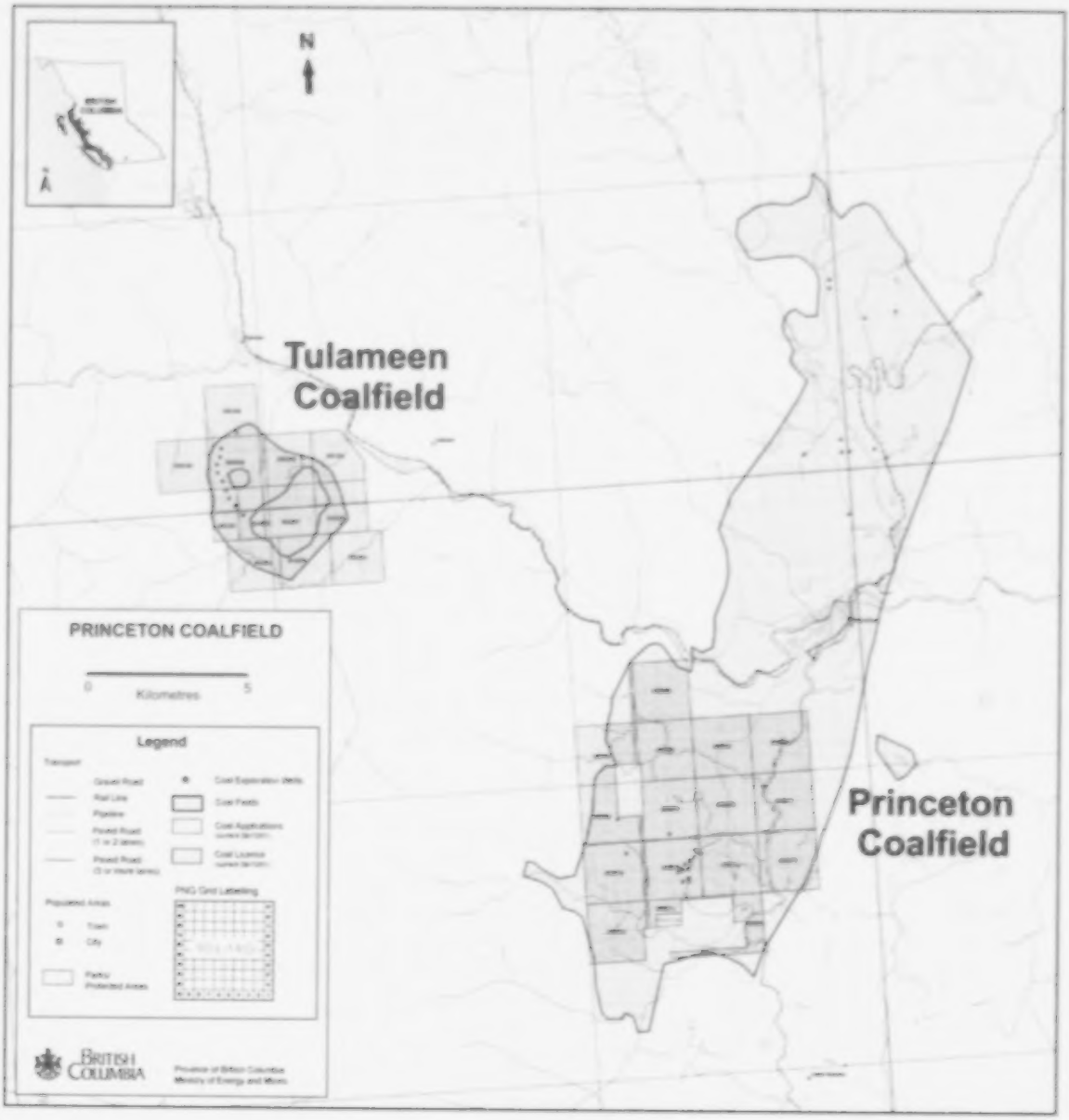



Map of Princeton and Tulameen Coalfields

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- In the area south of Princeton there are four major coal zones, numbered from one at the top to four at the base in about 530 metres of section in the Tertiary Allenby Formation.

Depth (m)
0
No. 1 Coal zone - 3 m
Interval - 105.1 m
No. 2 Coal zone - 26 m
The Tertiary Allenby Formation consists of conglomerate, sandstone, and shale interbedded with coal, carbonaceous siltstone and shale, and bentonite.
Interval - 196.1 m
No. 3 Coal zone - 30.4 m
Interval - 137.2 m
518
No. 4 Coal zone - 18.2 m

Generalized stratigraphic column (Dolmage and Campbell, 1975).

- The lowest zone (Number 4) ranges in thickness from 10 to 50 metres and is described as mainly dirty coal with a clean coal seam up to 2 metres thick near the top. The next (Number 3 zone) is 140 metres higher in the section and is about 30 metres thick. It is reported to contain up to two workable seams. The Number 2 zone contains 7.5 metres of coal in a 26-metre section and is 200 metres above the Number 3 zone. The Number 1 zone is 100 metres above the Number 2 zone and contains from 2 to 3 metres of coal.

- There were thirteen small underground mines and one surface mine that operated in the central part of the coalfield up until about 1961. About 2.1 million tonnes of high-volatile coal were produced prior to 1961.

Typical Dry Basis Analyses

| | |
|---|---|
| Volatile matter (%) | 33.3 - 34.4 |
| Fixed carbon (%) | 40.5 - 42.6 |
| Ash (%) | 23 - 26.1 |
| Sulphur (%) | 0.75 - 0.83 |
| Btu/lb | 9941 - 10,336 |
| Mj/kg | 23.1 - 24.0 |
| FSI | ND |
| Hardgrove Index | 39 - 45 |
| Rmax% | 0.52 |

(Ryan, 2002)

- In 2002, three coal exploration holes were drilled in the Princeton Coalfield and based on encouraging results the coalbed gas tenure was obtained by Petrobank. Since then the company has conducted two seismic surveys and as of early 2004 plans to drill a multi-hole pilot.

## Coalbed Gas

- Based on work to date, Petrobank estimates that the potential gas-in-place resource is 250-500 Bcf (Petrobank Energy and Resources Ltd. 2003 Annual Report).

## Key References (see Appendix I, References)

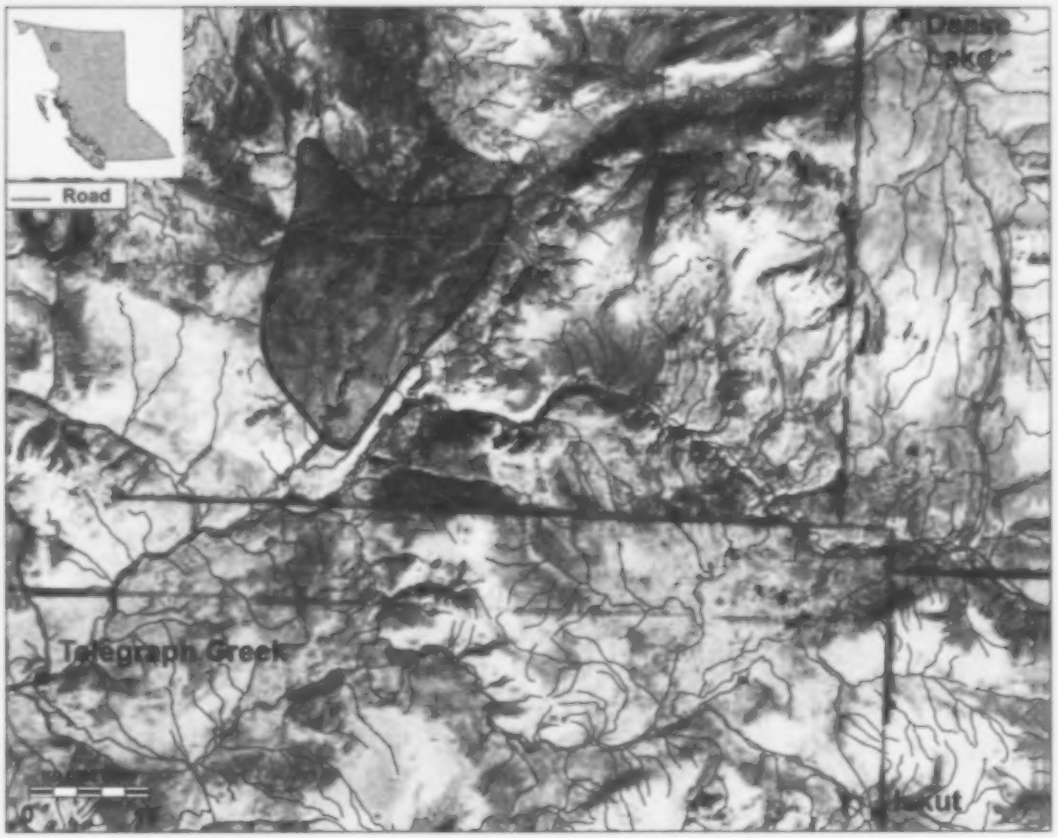
Ryan, B.D. (2002): Coal in British Columbia; *B.C. Ministry of Energy and Mines*, Website, www.em.gov.bc.ca/Mining/Geolsurv/coal/coalinbc/coal_bc.htm.

Ryan, B.D. (2003): A Summary of Coalbed Methane Potential in British Columbia; *Canadian Society of Exploration Geophysicists Recorder*, Vol.28, No.9, November 2003, pages 32-40.

Ryan, B.D. (2003): Overview of the Coalbed Methane Potential of Tertiary Coal Basins in the Interior of British Columbia; in Geological Fieldwork 2002, *B.C. Ministry of Energy and Mines*, Paper 2003-1, pages 213-236.

Smith, G.G. (1989): Coal Resources of Canada; *Geological Survey of Canada*, Paper 89-4, pages 29-68.

# Tuya River Coalfield



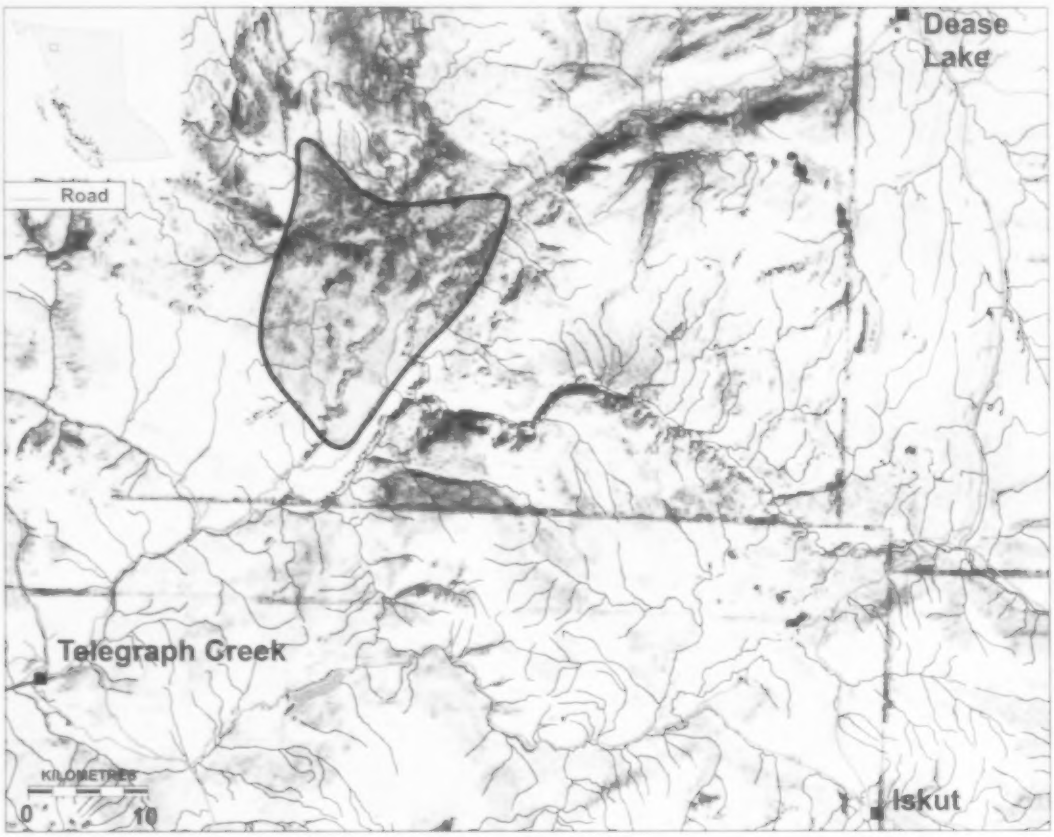

The Tuya River Coalfield is located between the communities of Dease Lake and Telegraph Creek in northwestern BC and straddles the drainage of Tuya River and its tributaries Little Tuya River and Mansfield Creek. These three drainages have incised meandering canyons up to 200 metres deep in an area of otherwise subdued relief.

The coal-bearing rocks are not younger than early Eocene and not older than Paleocene and may be equivalent to the Tango Formation of the Sustut Group. The coal zone is about 100 metres thick and contains up to 30 metres of high-volatile bituminous B coal.

The earliest recorded description of coal in the Tuya River area was in 1904 when seams up to 12 metres thick were described adjacent to Tuya River. The basin was explored in detail in the period 1979 to 1980, when 10 cored-holes were drilled and a number of hand trenches dug.

The basin covers approximately 150 square kilometres, potentially containing over 600 million tonnes of coal or about 400 million tonnes to a depth of 1600 metres. The coalbed gas resource is estimated to be 66 Bcf.

# Tuya River Coalfield

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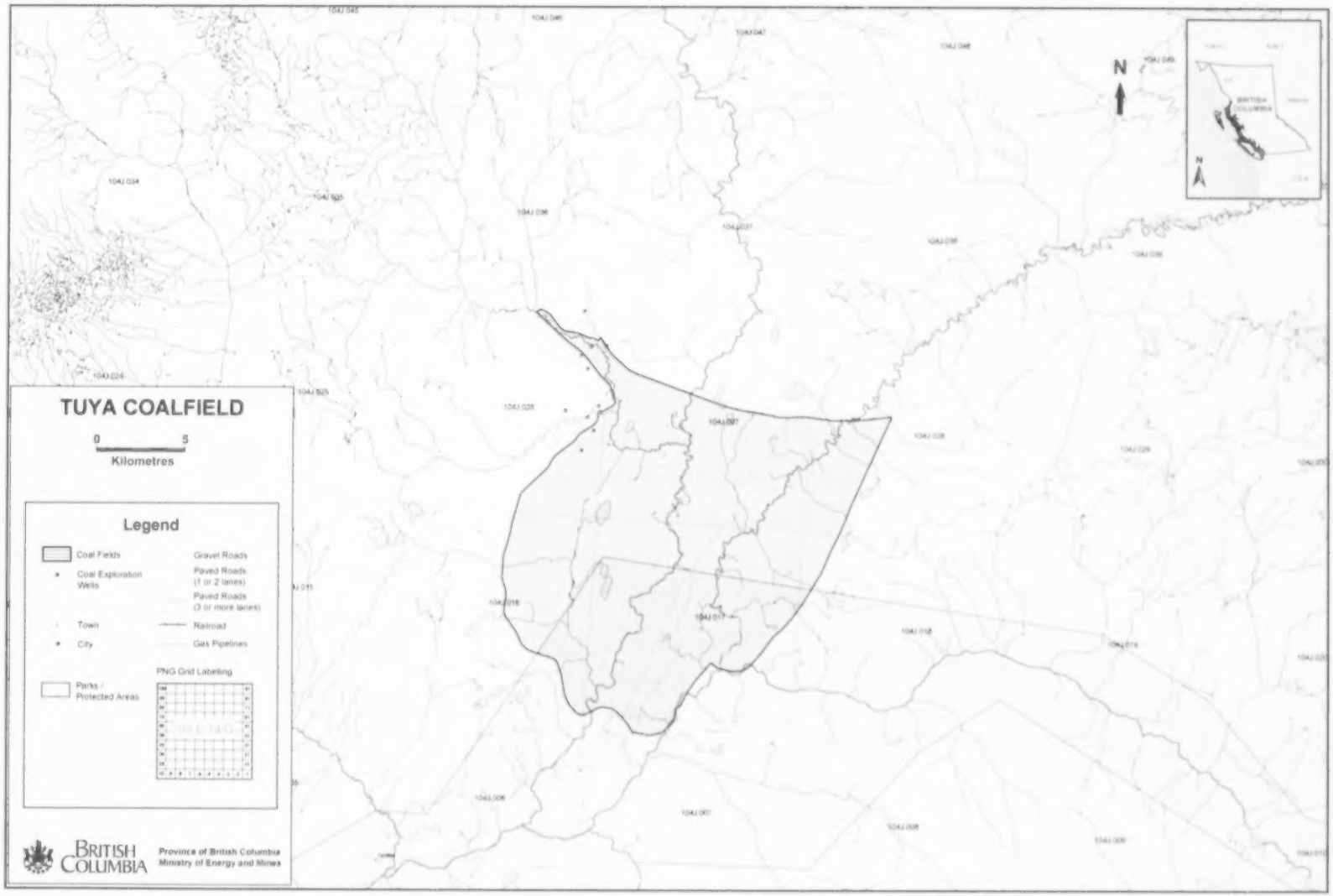
The basin covers approximately 150 square kilometres, potentially containing over 600 million tonnes of coal or about 400 million tonnes to a depth of 1600 metres. The coalbed gas resource is estimated to be 66 Bcf.




Map of Tuya Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

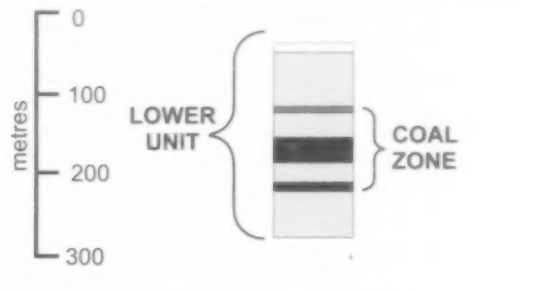
- The stratigraphic succession of the Tuya River coalfield contains two units of Paleocene to Eocene age, possibly equivalent to the Tango Formation of the Sustut Group. The upper unit, which is at least 300 metres thick, is composed of volcanic-pebble conglomerate, sandstones and volcanic rocks. The lower unit is 200 to 300 metres thick and contains a single coal-bearing zone. The zone is about 100 metres thick and includes from 5 to 30 metres of coal. The structure of the basin is that of an open, northerly-plunging syncline complicated by smaller scale faults and folds.

- To date, exploration consists of mapping and drilling in the western half of the basin by PetroCanada (Reid, 1980; De Nys, 1980) and mapping of the eastern half by Esso Minerals Canada (Vincent, 1979). Ten cored holes were drilled and a number of hand trenches dug.

- The coal, which has a rank of high volatile bituminous B, is hard, well-cleated and contains a moderate amount of amber.

- The basin contains about 400 million tonnes of coal within 1600 metres of surface (Ryan, 2003).

- A subsidiary basin or extension of the Tuya River Coalfield outcrops 20 kilometres southwest of Tuya River in the lower reaches of the Tahltan River. Lignite coal zones ranging up to 4 metres in thickness occur.




Representative stratigraphic column of the Tuya River Coalfield; modified from Ryan (1991).

| Typical Average Raw Analysis (on an as-received basis) | |
|---|---|
| Moisture (%) | 12.4 |
| Volatile matter (%) | 30.7 |
| Fixed carbon (%) | 37.8 |
| Ash (%) | 19.1 |
| Sulphur (%) | 0.5 |
| Btu/lb | 7,740 |
| Mj/kg | 18 |
| Hardgrove Index | 53 |
| Rmax% | 0.6 - 0.8 |

(Ryan, 2002)

## Coalbed Gas

- The Tuya River Coalfield was mapped and the coalbed gas resource appraised in 1991 (Ryan 1991).

- A potential coalbed gas resource of up to 66 Bcf may exist in the basin (Ryan, 1991). Most of this resource would be biogenic methane because of the low rank.

## Key References (see Appendix I, References)


De Nys, F.J.G. (1980): Thundercloud Coal Project Technical Report; PetroCanada Exploration, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report 243.

Reid, J.L. (1980): Thundercloud Coal Project Technical Report, PetroCanada Exploration, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Coal Assessment Report 242.

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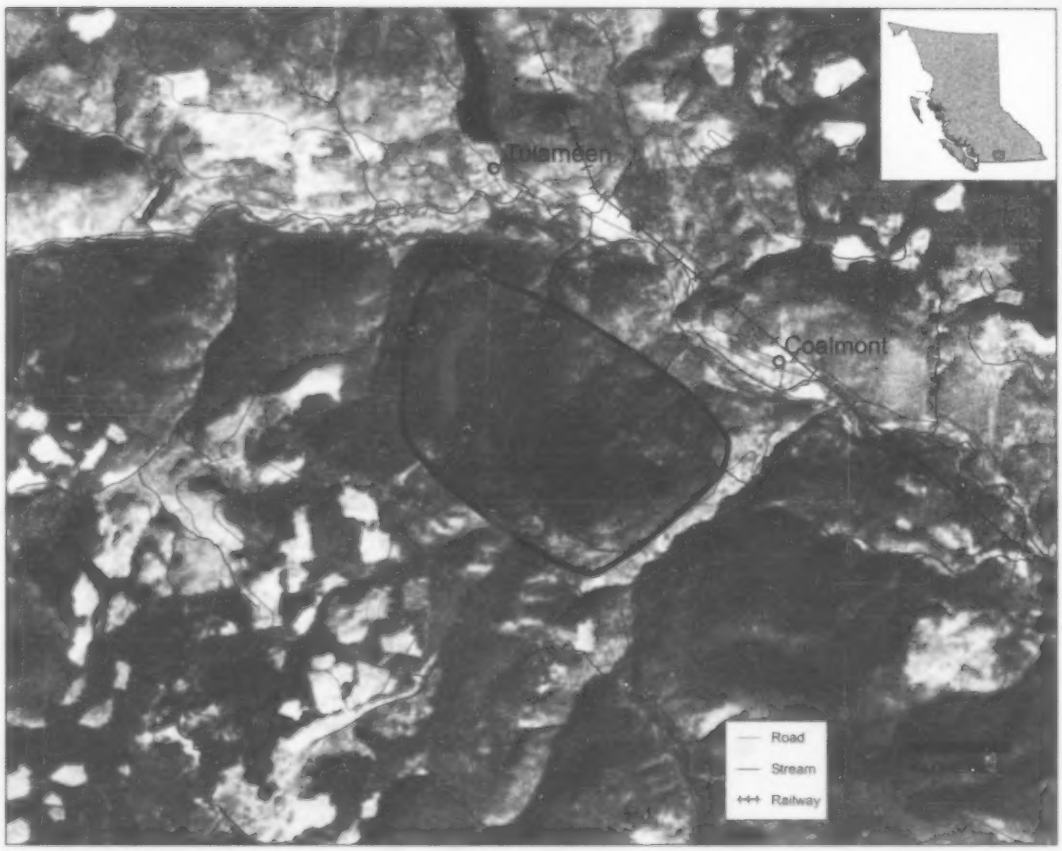
Ryan, B.D. (2002): Coal in British Columbia; *B.C. Ministry of Energy and Mines*, Website www.em.gov.bc.ca/mining/geolsurv/coal/coalinbc/coal_bc.htm

Ryan, B.D. (2003): A Summary of Coalbed Methane Potential in British Columbia; *Canadian Society of Exploration Geophysicists Recorder*, Vol.28, No.9, November 2003, pages 32-40.

Vincent, B.D. (1979): Geological Mapping, Tuya River Property, British Columbia: Esso Minerals Canada; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Coat Assessment Report 246.

# Tulameen Coalfield

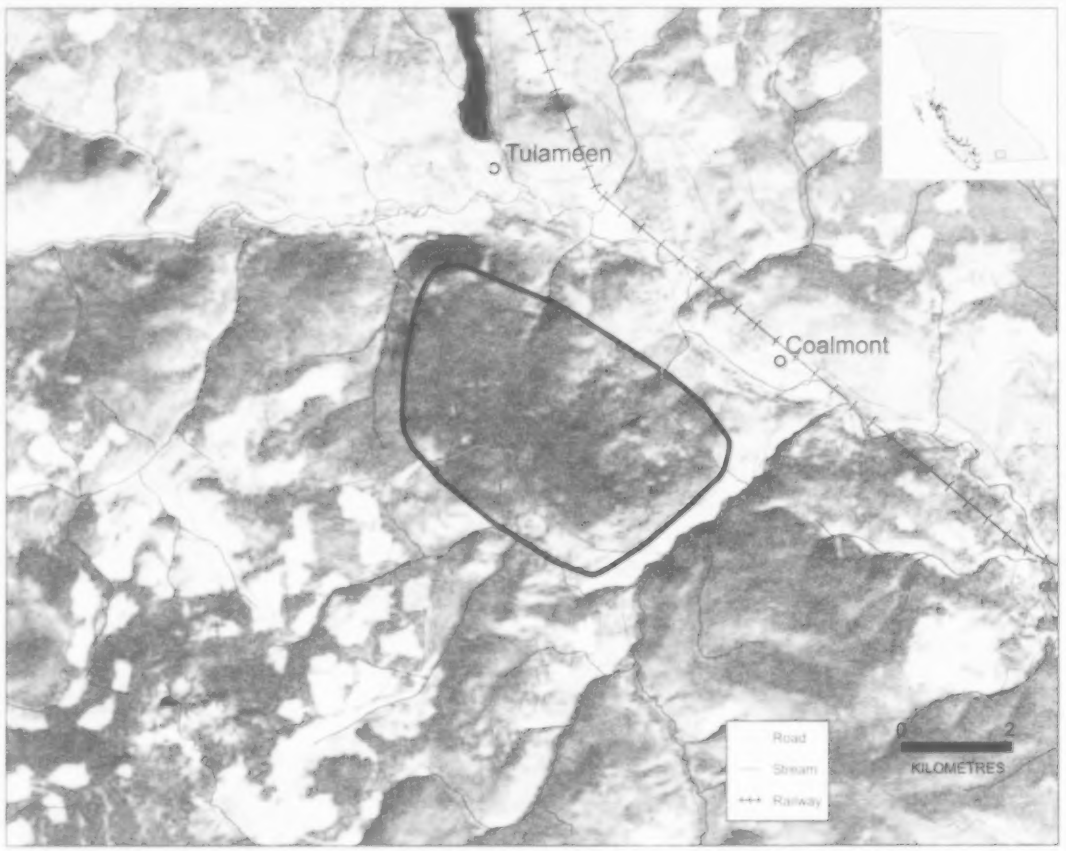



The Tulameen Coalfield is located in the south-central part of the province, 20 kilometres northwest of Princeton. It forms an elliptical sedimentary basin 5 by 4 kilometres in size and contains two well-developed thick seams of high-volatile B bituminous rank. The area underlain by coal is about 10 square kilometres. Underground mining from 1919 to 1940, produced about 2 million tonnes.

The Tertiary stratigraphy in the coalfield is assigned to the Allenby Formation and is subdivided into five units that consist of a lower conformable volcanic unit, three sedimentary units and an uppermost non-conformable volcanic unit. The middle sedimentary unit, which is about 130 metres thick, contains shales and two major coal seams. The upper sedimentary unit consists of conglomerates and sandstones and is at least 400 metres thick. The rocks are folded into a broad syncline. Based on the synclinal form of the coal horizon there is a potential coal resource of at least 300 million tonnes.

There is a potential coalbed gas resource of 50 Bcf in the coalfield.

# Tulameen Coalfield

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There is a potential coalbed gas resource of 50 Bcf in the coalfield.

## Coal

- The coal-bearing section contains two coal seams though they tend to be very dirty with partings of shale and bentonite. The lower seam is 7 to 8 metres thick and the upper seam 15 to 21 metres thick. The seams are thought to underlie the whole coalfield.

- Underground mining carried out in the area began in 1919 and ended in 1940; the mines extracted about 2 million tonnes. Renewed interest in the 1950s led to surface mining that extracted a further 150,000 tonnes of coal. There was exploration in the coalfield in the 1970s and 1980s and a major exploration program in 1998. In 1999, a bulk sample was test-washed with favourable results.

- At present, Compliance Energy Corp. has started mining on a small scale and is trucking coal to local markets; the company has expressed interest in the coalbed gas potential.

- Based on the synclinal form of the coal horizon there is a potential coal resource of at least 300 million tonnes (Ryan, 2003).

## Coalbed Gas

- A potential coalbed gas resource of 50 Bcf is estimated for the coalfield (Ryan, 2003).

## Key References (see Appendix I, References)

Ryan, B.D. (2002): Coal in British Columbia; *B.C. Ministry of Energy and Mines*, Website www.em.gov.bc.ca/Mining/Geolsurv/coal/coalinbc/coal_bc.htm.

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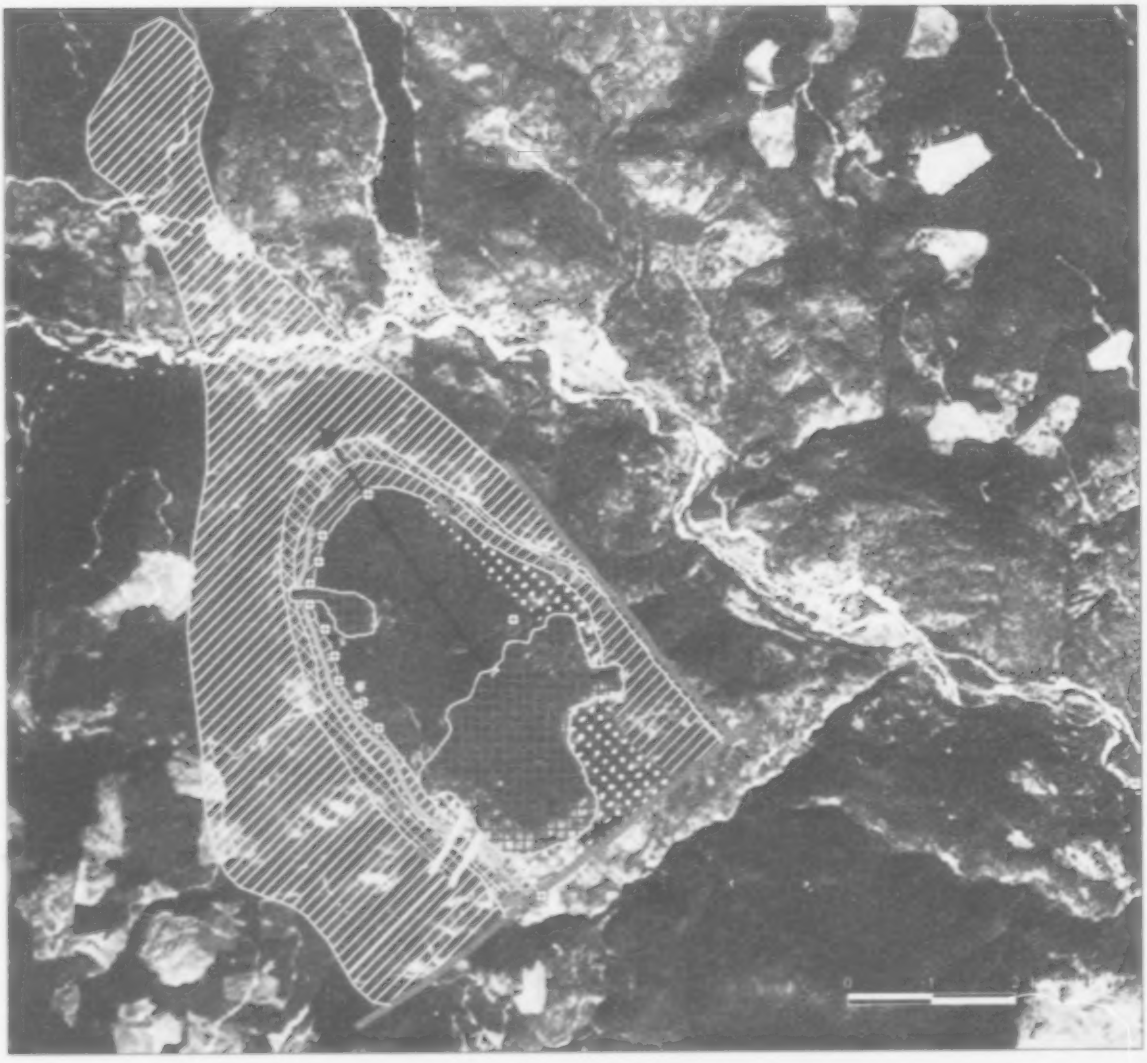
## Tulameen Coalfield



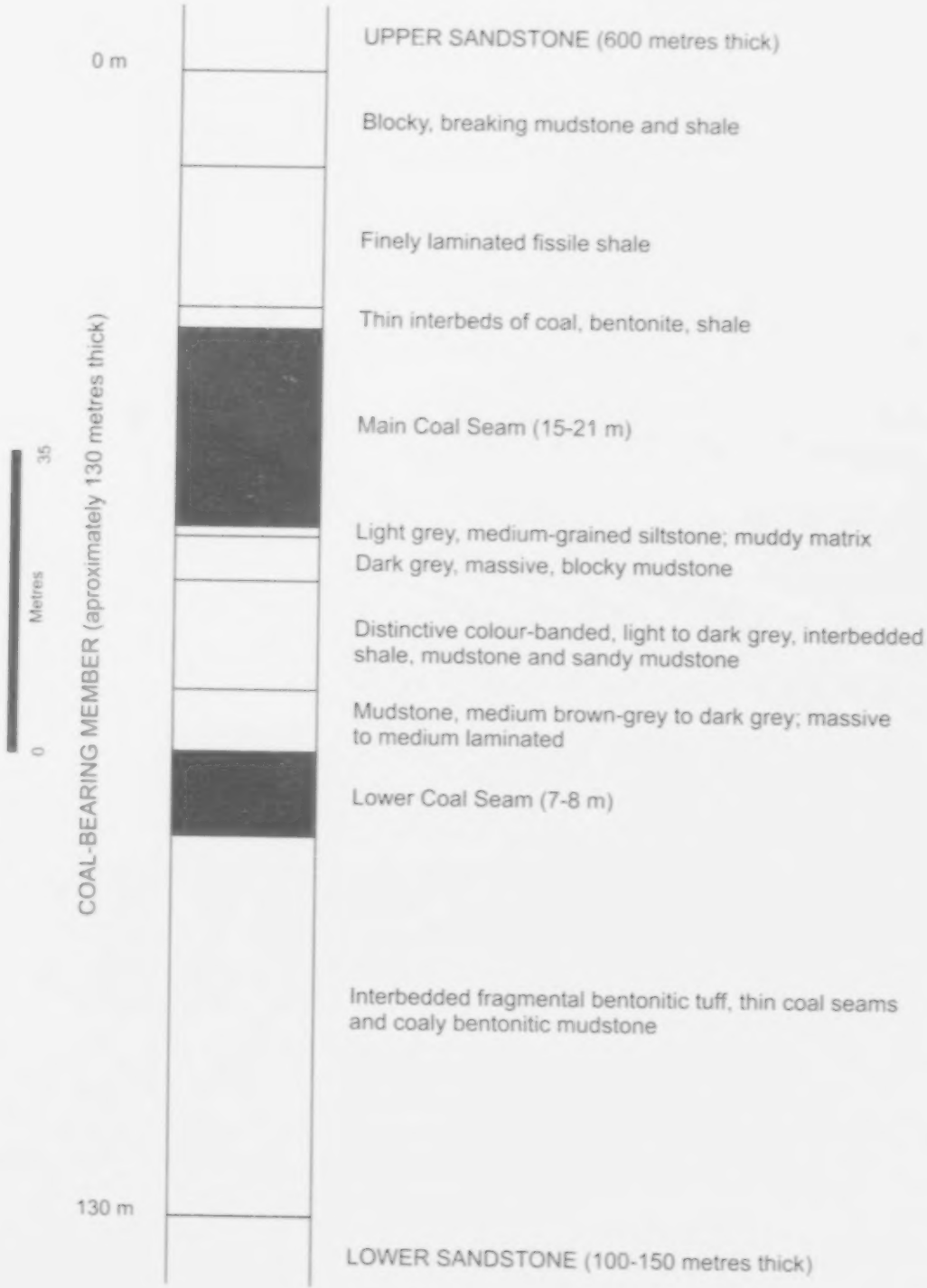
LEGEND

- CHILCOTIN GROUP (basalt)
- PRINCETON GROUP
  - Allenby Formation
    - Summer Creek sandstone
    - Vermillion Bluffs shale
    - Hardwicke sandstone
  - Cedar Formation (volcanics)
- Borehole
- Adit
- Geological contacts
- Coal seam
- Fault
- Syncline

Typical Dry Basis Analyses

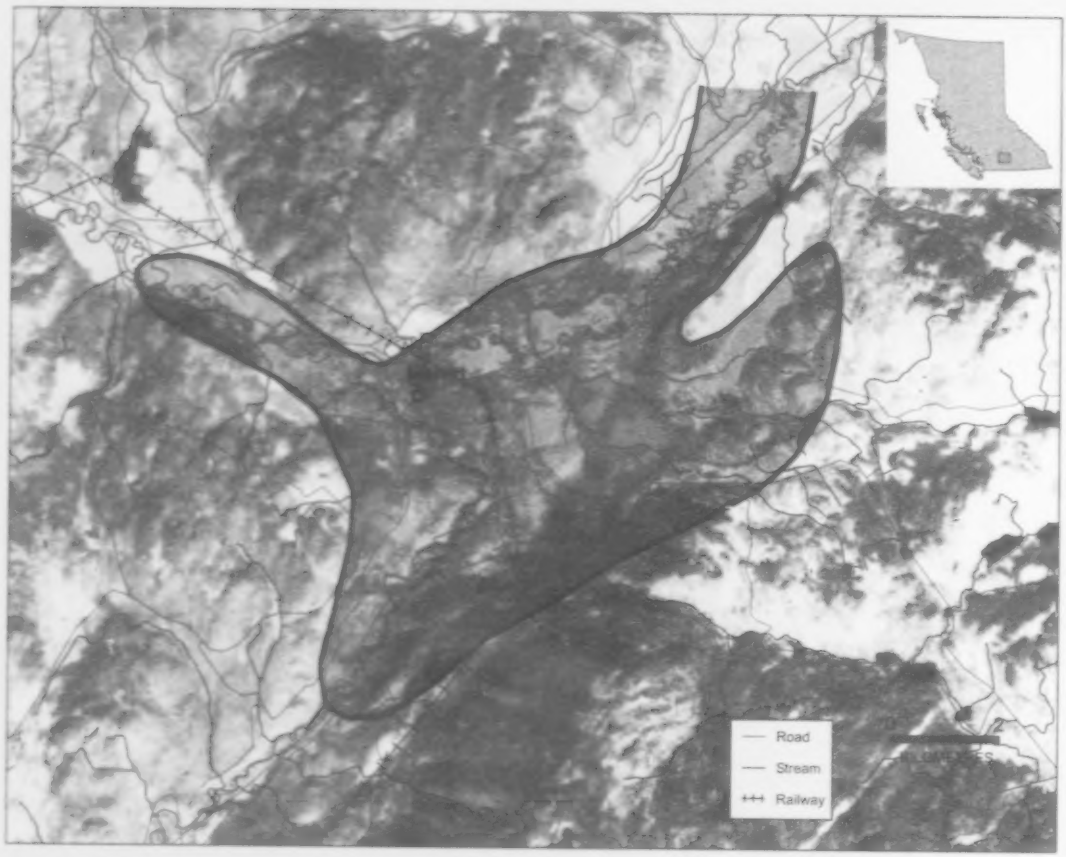
| | |
|---|---|
| Volatile matter (%) | 37.4 |
| Fixed carbon (%) | 42.52 |
| Ash (%) | 20.22 |
| Sulphur (%) | 0.44 - 0.66 |
| Btu/lb | 10,828 |
| Mj/kg | 25.2 |
| FSI | ND |
| Hardgrove Index | 39 - 45 |
| Rmax% | 0.62 - 0.86 |

(Ryan, 2002)


0 m
UPPER SANDSTONE (600 metres thick)
Blocky, breaking mudstone and shale
Finely laminated fissile shale
Thin interbeds of coal, bentonite, shale
Main Coal Seam (15-21 m)
Light grey, medium-grained siltstone; muddy matrix
Dark grey, massive, blocky mudstone
Distinctive colour-banded, light to dark grey, interbedded shale, mudstone and sandy mudstone
Mudstone, medium brown-grey to dark grey; massive to medium laminated
Lower Coal Seam (7-8 m)
Interbedded fragmental bentonitic tuff, thin coal seams and coaly bentonitic mudstone
130 m
LOWER SANDSTONE (100-150 metres thick)
COAL-BEARING MEMBER (aproximately 130 metres thick)
0
Metres
35

Representative stratigraphic column. The coal-bearing middle member of the Tertiary Allenby Formation is approximately 130 metres thick and consists of interbedded shales, mudstone, tuffs, minor sandstone and coal (Williams, 1978).

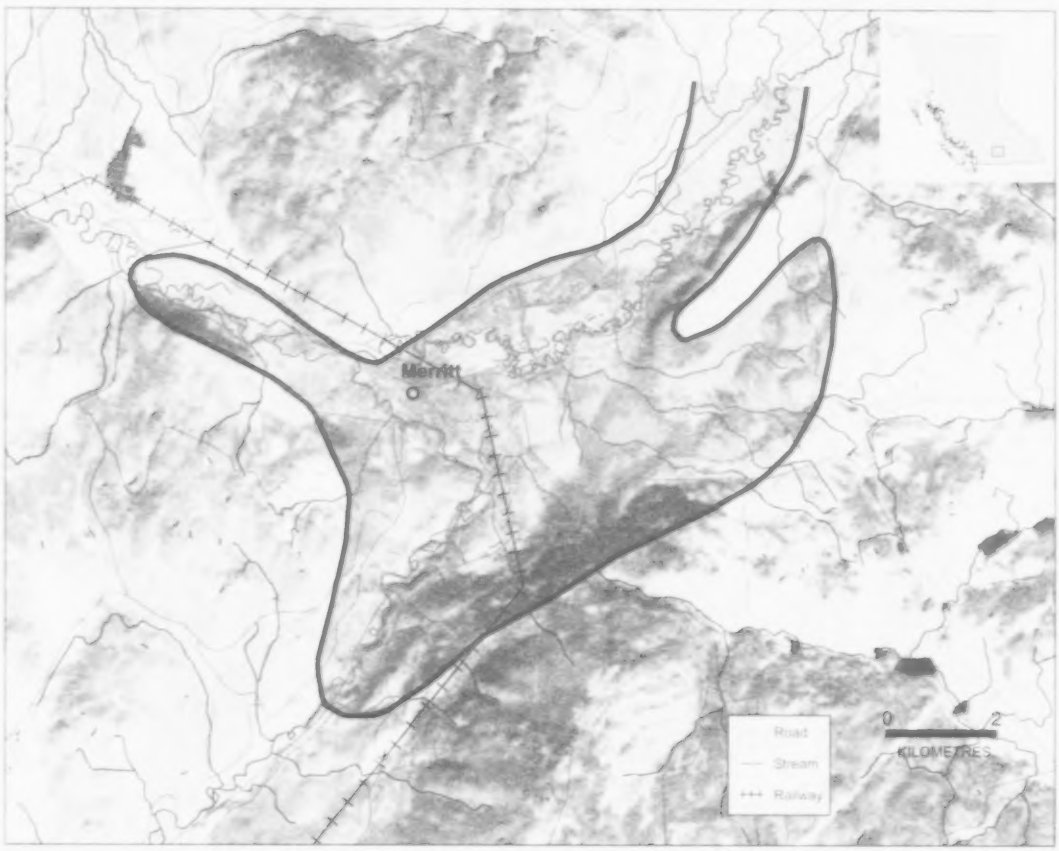
# Merritt Coalfield




The Merritt Coalfield is located in the south-central part of the province and comprises several isolated Tertiary sedimentary areas which in part underlie the town of Merritt and adjacent areas. The coal-bearing sedimentary rocks are assigned to the Coldwater Formation. The main area, which is under and south of Merritt, covers about 80 square kilometres. A smaller area to the east is about 25 square kilometres in size and has not been extensively explored. The Merritt area, which contains high-volatile C to A bituminous coal, was explored in 1945 and 1960 and about 2.4 million tonnes of coal were produced.

There appear to be seven seams with a cumulative coal thickness of 22 metres in a 250-metre section. It is difficult to estimate the resource in the area but if a cumulative coal thickness of 10 metres extends through the whole coalfield, then there could be over 800 million tonnes and a moderate coalbed gas resource of over 50 Bcf under the town of Merritt.

# Merritt Coalfield

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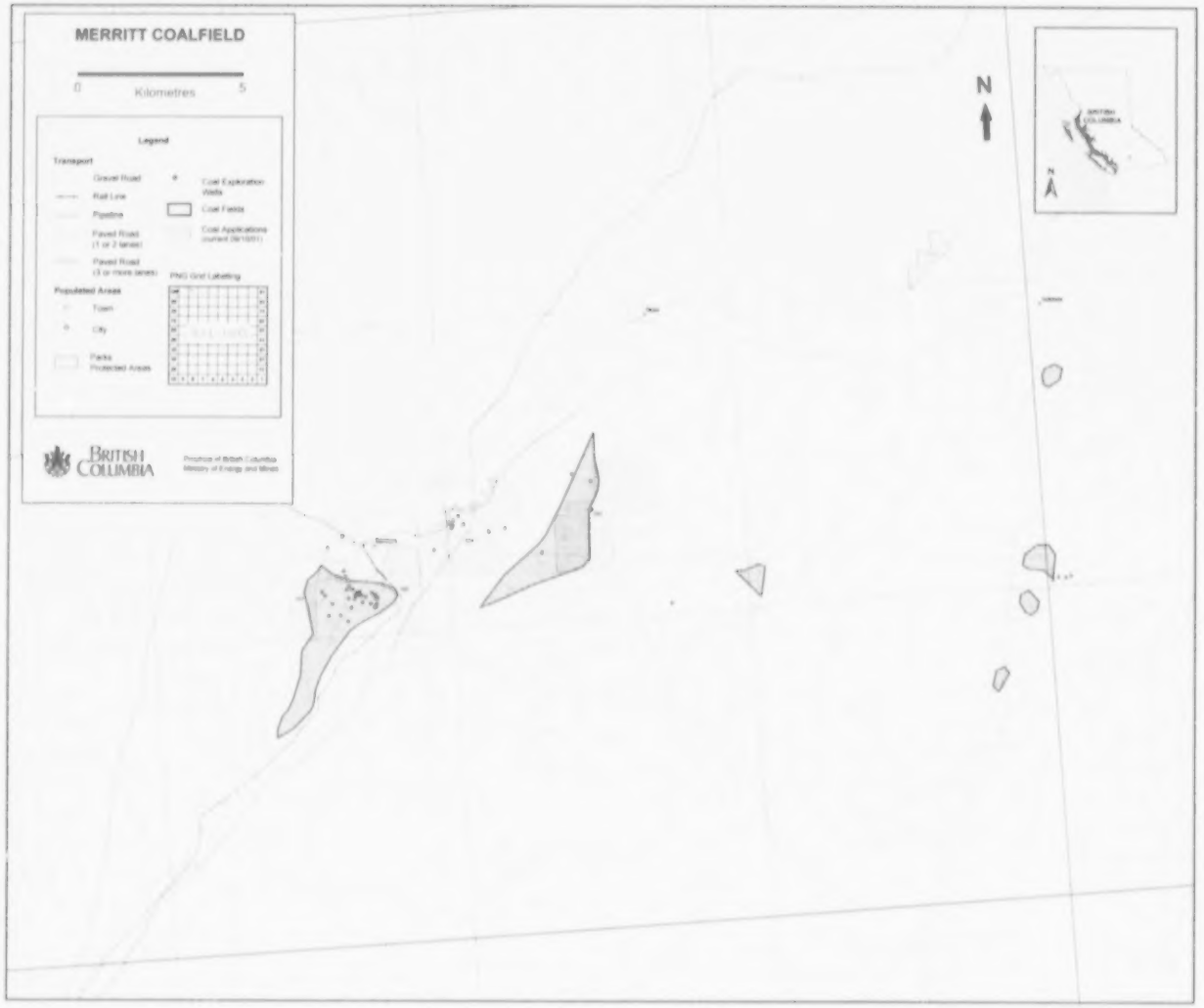


Map of Merritt Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- The Merritt Coalfield contains high-volatile C to A bituminous coal. From 1906 to 1963, underground mines produced 2.4 million tonnes based on exploration that outlined about 10 million tonnes of underground mineable coal. Overall, the Merritt Coalfield has not been extensively explored.

- There appear to be seven seams with a cumulative coal thickness of 22 metres in a 250-metre section in the Tertiary Coldwater Formation.

- It is difficult to estimate the resource in the area but if a cumulative coal thickness of 10 metres extends through the whole coalfield, then there could be over 800 million tonnes (Ryan, 2003).

## Coalbed Gas

- There could be a moderate coalbed gas resource of over 50 Bcf under the town of Merritt (Ryan, 2003).

- A company has acquired freehold coal rights in the area and hopes to drill coal exploration holes that will provide some information on the coalbed gas potential.

## Key References (see Appendix I, References)


Matheson, A. (1992): Subsurface Thermal Coal Sampling Survey, Merritt Coal Deposits, South-Central British Columbia; in Geological Fieldwork 1991, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1992-1, pages 427-432.

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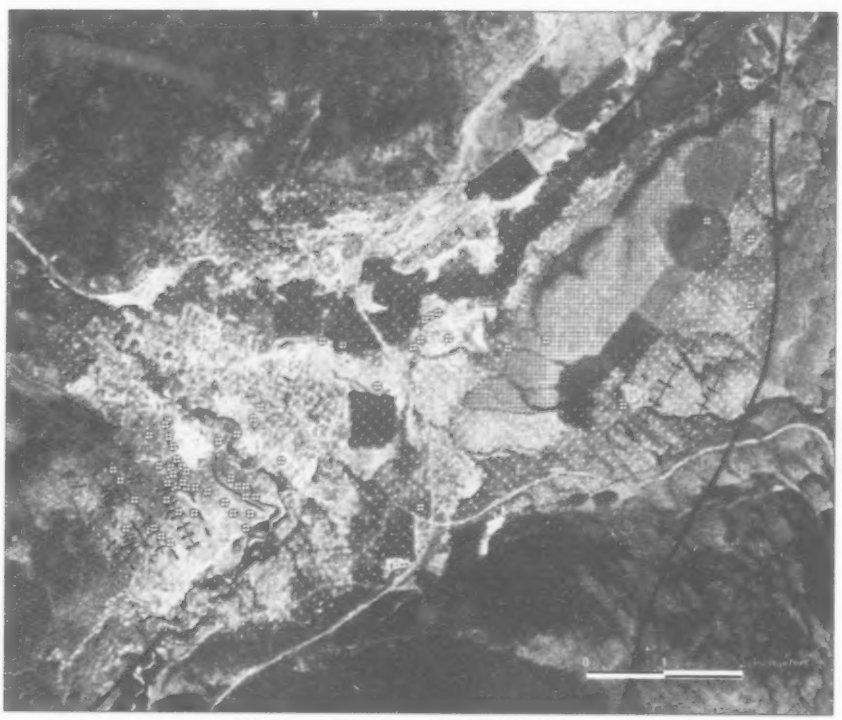
Smith, G.G. (1989): Coal Resources of Canada; *Geological Survey of Canada*, Paper 89-4, pages 29-68.

## Merritt Coalfield

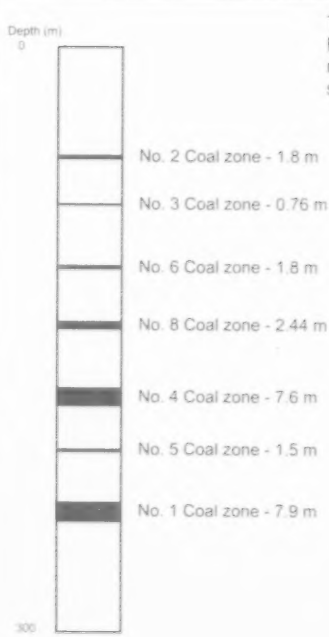


**LEGEND**

- "Valley Basalt"

PRINCETON GROUP

- Coldwater Formation
- Volcanics
- Geological Contact
- Coal seam
- Fault (within basin)
- Fault (regional)
- Anticline
- Syncline
- Borehole
- Adit




The Tertiary Coldwater Formation is a sequence of nonmarine conglomerate, sandstone, shale and coal.

No. 2 Coal zone - 1.8 m

No. 3 Coal zone - 0.76 m

No. 6 Coal zone - 1.8 m

No. 8 Coal zone - 2.44 m

No. 4 Coal zone - 7.6 m

No. 5 Coal zone - 1.5 m

No. 1 Coal zone - 7.9 m

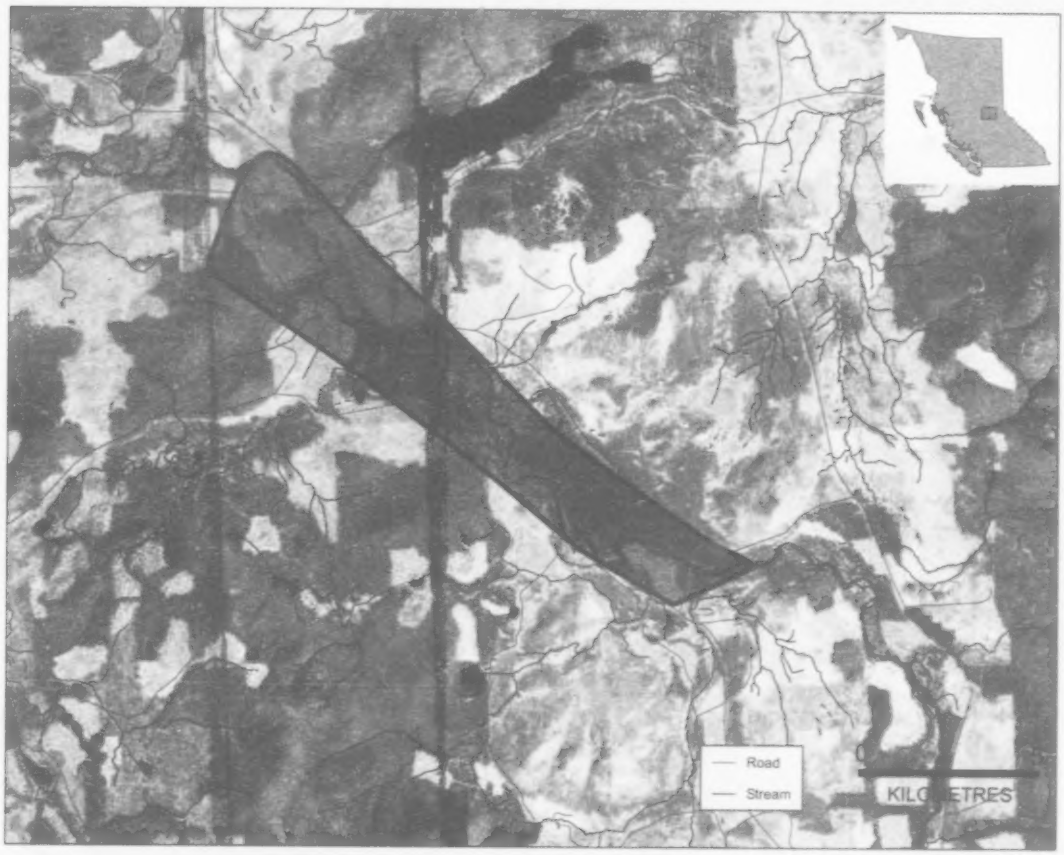
Generalized stratigraphic column (Matheson, 1992).

### Typical Air-Dried Analysis

| | |
|---|---|
| Moisture (%) | 5.0 |
| Volatile matter (%) | 34.0 |
| Fixed carbon (%) | 52.0 |
| Ash (%) | 9.0 |
| Sulphur (%) | 0.5 |
| Btu/lb | 12,500 |
| Mj/kg | 29.08 |
| FSI | 3 |
| Hardgrove Index | 57 |
| Rmax% | 0.64 - 0.86 |

(Ryan, 2002)

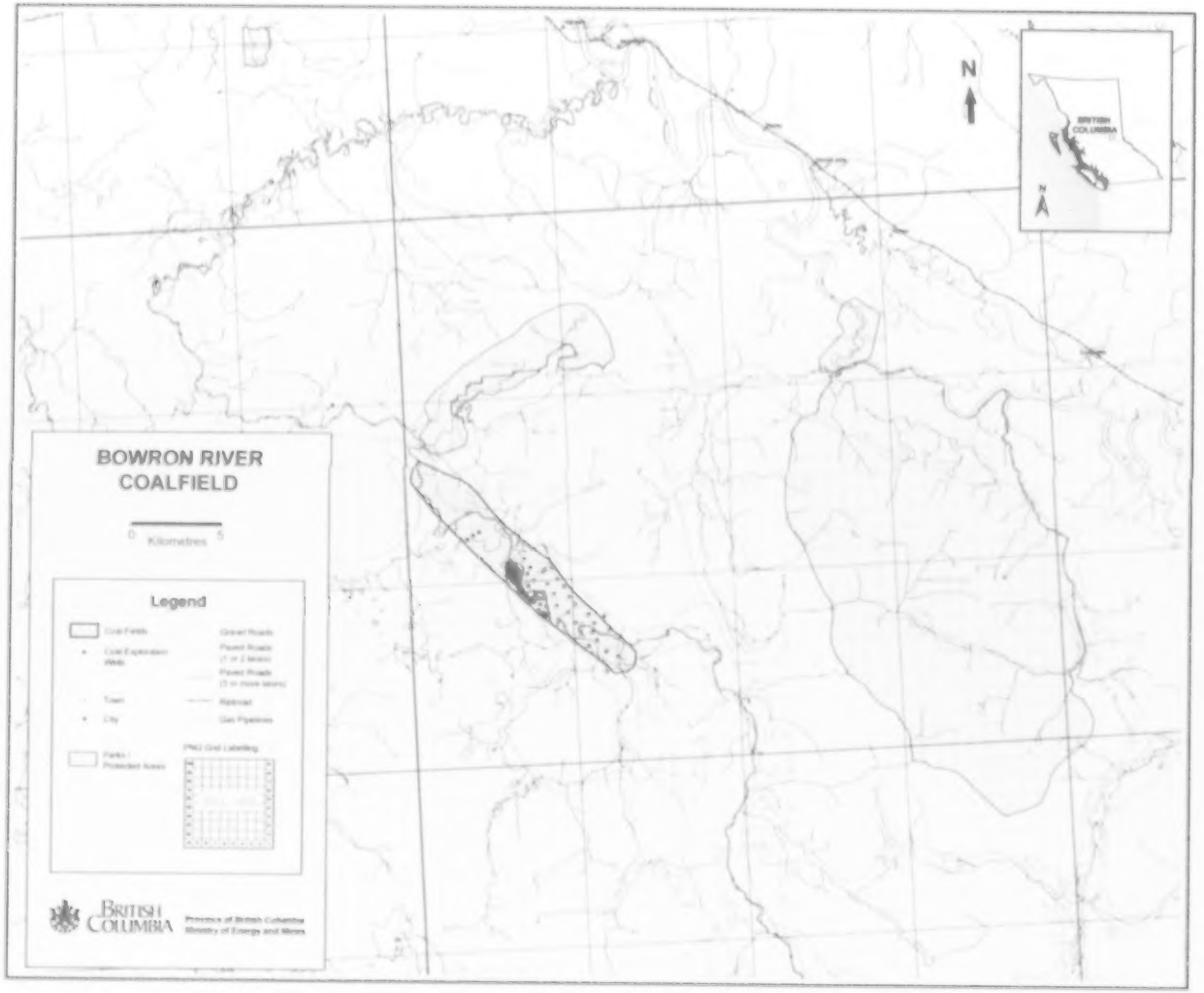
# Bowron River Coalfield




The Bowron River Coalfield is located in the east-central part of the province, 50 kilometres east-southeast of Prince George. The coalfield is 2.5 kilometres wide and 15 kilometres long. Coal was first reported in 1871, however, it was not until 1910-11 that development work started with the construction of an adit and survey of the area.

The lower 85 metres of the more than 700 metre thick Tertiary sedimentary section is coal-bearing. Seams dip at 20 to 60 degrees to the northeast. The section contains at least three seams with a cumulative thickness of 8.5 metres. The coal, which is high-volatile B bituminous in rank, is characterized by a high amber content (8 per cent). Considering only the lower seam, there is an estimated potential resource of 400 million tonnes down to a depth of 1200 metres.

Any coalbed gas potential will depend on the presence of biogenic methane though the presence of amber may help initiate generation of thermogenic methane at a lower rank. There could be a coalbed gas resource of about 40 Bcf.

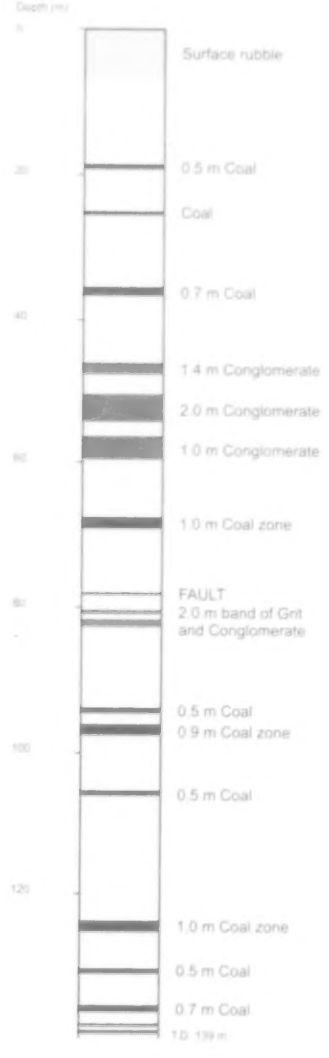



Map of Bowron River Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- The lower 85 metres of the more than 700 metre thick Tertiary sedimentary section is coal bearing.


Depth (m)
0
20
40
60
80
100
120
Surface rubble
0.5 m Coal
Coal
0.7 m Coal
1.4 m Conglomerate
2.0 m Conglomerate
1.0 m Conglomerate
1.0 m Coal zone
FAULT
2.0 m band of Grit
and Conglomerate
0.5 m Coal
0.9 m Coal zone
0.5 m Coal
1.0 m Coal zone
0.5 m Coal
0.7 m Coal
T.D. 139 m
Predominantly flaser-bedded quartz arenites with rippled shale streaks containing occasional horizons exhibiting discrete burrows and other bioturbation. Poorly sorted bands of grit and conglomerate up to two metres occur intermittently. Coalified plant material, coal spar and root structures are scattered throughout. Coal lenses, bands and seams are abundant. Amber occurs in the coal, podzols and carbonaceous shales. Slickensiding is common.

Simplified stratigraphic column. Diamond-drillhole GSB-90-3 is sited along strike of the coal zone, close to the western fault and the southwest bank of the Bowron River (Matheson and Sadre, 1991).

- The coal section dips at 20 to 60 degrees to the northeast and contains at least three seams with a cumulative thickness of 8.5 metres. Coal rank is high-volatile B bituminous and is characterized by a high amber content (8 per cent).

- There has been some underground exploration but no mining and no exploration since 1990.

| Average Dry Basis Analysis | |
|---|---|
| Volatile matter (%) | 36.7 |
| Fixed carbon (%) | 42 |
| Ash (%) | 24.6 |
| Sulphur (%) | 1.39 |
| Btu/lb | 11,000 |
| Mj/kg | 25.59 |
| FSI | 1 - 3 |
| Hardgrove Index | 58 |
| Rmax% | 0.65 |

(Ryan, 2002)

- Considering only the lower seam, Matheson and Sadre (1991) estimated a potential resource of 400 million tonnes down to a depth of 1200 metres.

## Coalbed Gas

- Any coalbed gas potential will depend on the presence of biogenic methane though the presence of amber may help initiate generation of thermogenic methane at a lower rank.

- There could be a coalbed gas resource of about 40 Bcf (Ryan, 2003).

## Key References (see Appendix I, References)


Matheson, A. and Sadre, M. (1991): Subsurface Coal Sampling Survey, Bowron River Coal Deposits, Central British Columbia; in Geological Fieldwork 1990, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Paper 1991-1, pages 391-397.

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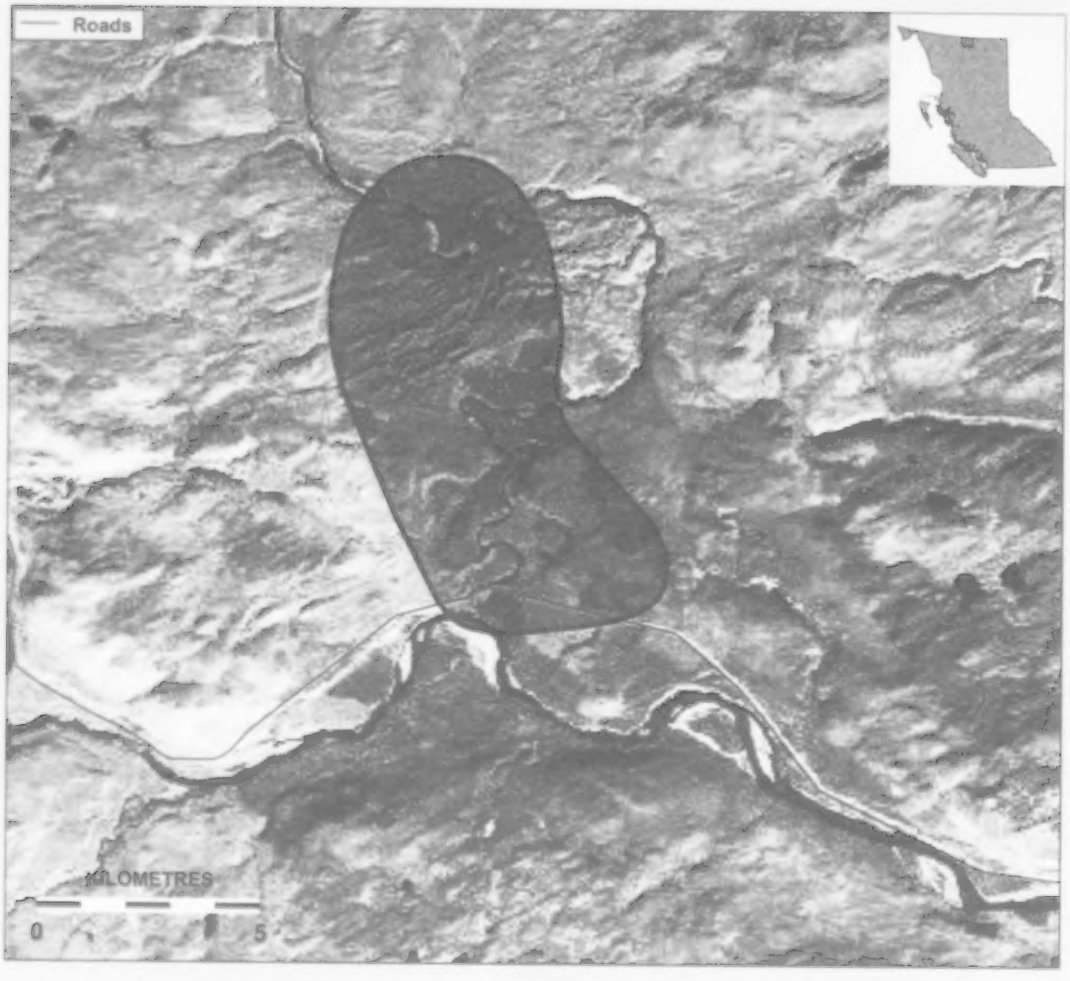
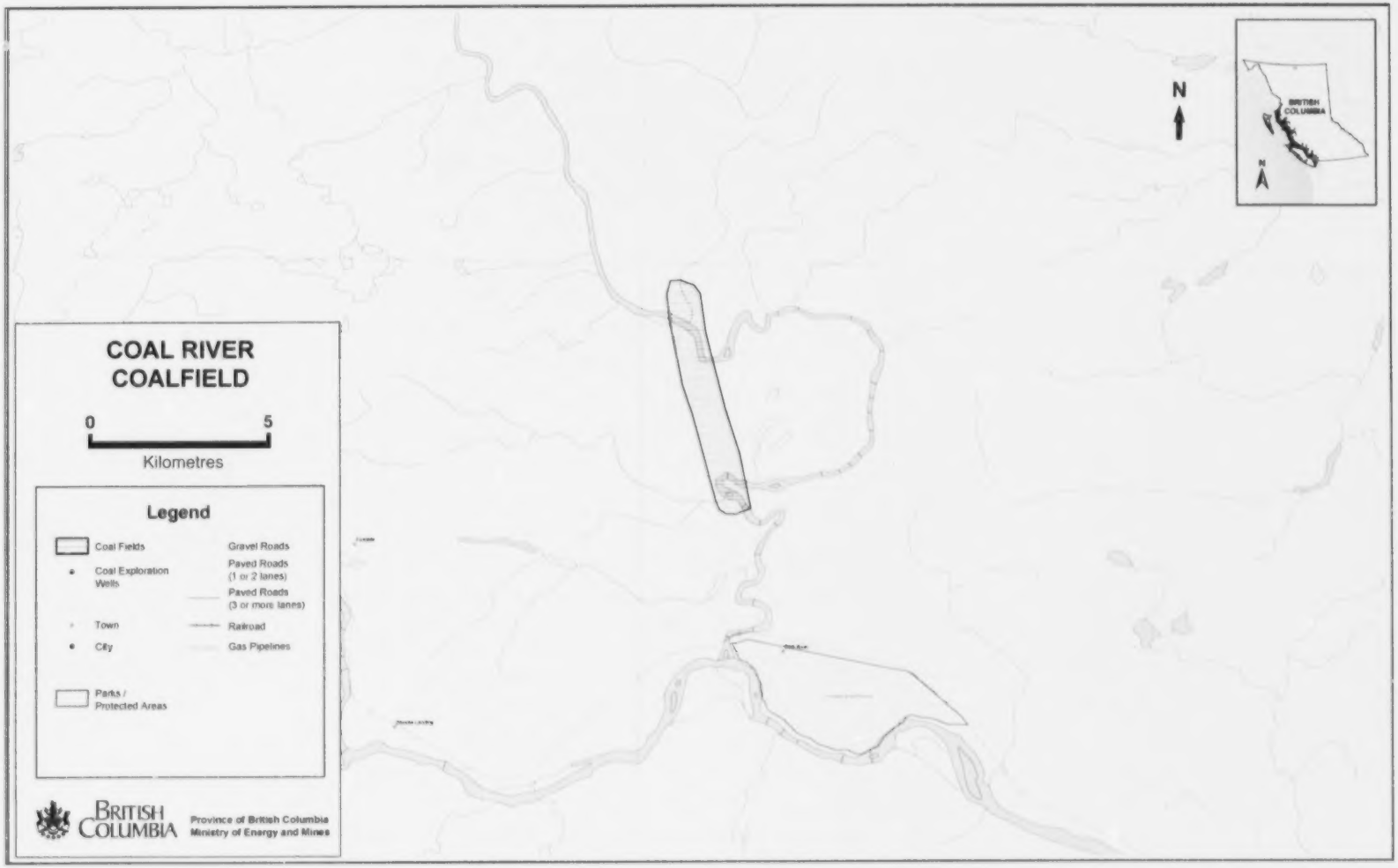
# Coal River Coalfield




The Coal River Coalfield is located in northern British Columbia between the Yukon border and the Liard River and is crossed by the Alaska Highway in the south. About 10 kilometres north of the highway, Coal River cuts through an area of Tertiary rocks exposing a single seam of lignite. The complete seam is not exposed but partial seam thicknesses range up to 8 metres.

Boulders of coal were first reported at the mouth of Coal River (in the Liard River) in 1891 but it wasn't until the early 1940s that a Geological Survey of Canada field-crew located the source. The coalfield was examined in 1990 by the Provincial geological survey in order to further delineate the deposit.

The basin covers an area of about 35 square kilometres and contains an estimated lignite resource of 100 million tonnes with a possible coalbed gas resource of 6 Bcf.




Map of Coal River Coalfield

PDF files of Regional Coalbed Gas Maps available at: www.em.gov.bc.ca/subwebs/oilandgas/resource/cbg/maps.htm

## Coal

- In 1891, transported lignite boulders were reported near the mouth of Coal River (in the Liard River) by R.G. McConnell of the Geological Survey of Canada (GSC). In the early 1940s, M.Y. Williams (GSC) tracked the boulders to their source, approximately 10 kilometres up from the mouth of Coal River. The area was mapped in 1958 and 1960 by H. Gabrielse (GSC) and further examined in 1989 and 1990 (Ryan, 1996). The deposit has not been drilled.

- Coal River cuts through an area of Tertiary rocks exposing a single seam of lignite. The complete seam is not exposed but partial seam thicknesses range up to 8 metres.

- The lignite is overlain by clay which is at least 10 metres thick and is a near white, plastic clay. A darker plastic clay underlies the lignite.

- Tertiary outcrops are restricted to the riverbanks; trees, swamp and a burn zone cover the rest of the area. The area around the river is marked by large crescent-shaped slumps, possibly where younger sediments have slid on the underlying clay layer.

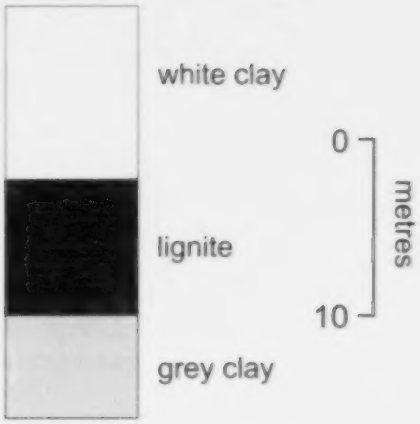
- A water-well drilled near where the Coal River crosses the Alaska Highway intersected 15 metres of coal at a depth of 15 metres. This may or may not be the same seam that outcrops 10 kilometres up Coal River.

- The lignite is cleated with two sets generally developed.

- Based on thickness data, the possible extent of the basin and by using a conservative 5 metre lignite thickness, a potential resource estimate of about 100 million tonnes exists (Ryan, 2002).

| Average Air-Dried Analysis | |
|---|---|
| Moisture (%) as-received | 9.4 |
| Moisture (%) air-dried | 13.8 |
| Volatile matter (%) | 41.18 |
| Fixed carbon (%) | 29.94 |
| Ash (%) | 4.84 |
| Sulphur (%) | 0.15 |
| Btu/lb | 9785 |
| Mj/kg | 22.76 |
| Rmax% | 0.2 |

(Ryan, 2002)




Representative stratigraphic column of the Coal River lignite occurrence.

## Coalbed Gas

- The rank is too low for generation of thermogenic methane, however, the lignite may contain reasonable quantities of biogenic methane.
- A lignite resource of about 100 million tonnes could contain a coalbed gas resource of about 6 Bcf depending on its ability to retain free gas and its ability to adsorb gas (Ryan, 2003).

## Key References (see Appendix I, References)

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